

NATIONAL GEOGRAPHIC

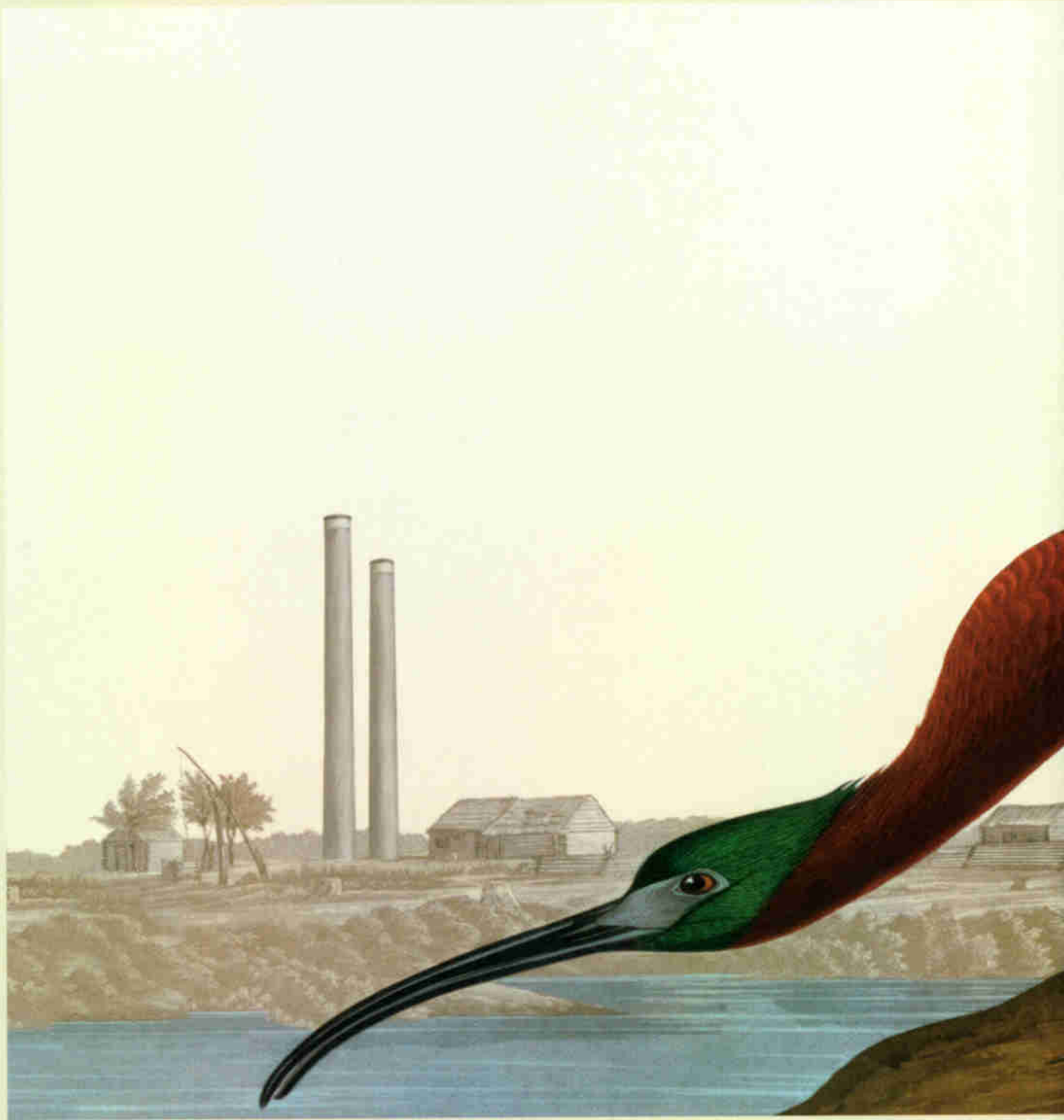


stem cells

**HOW FAR
WILL WE GO?**

China's Great Armada 28 Deadly Jellyfish of Australia 54
Mars: The Little Rovers That Could 58 Bitter Days for Chechnya 78
Tapping the Rockies 92 Glen Echo Pops Up 114

Glossy Ibis
NATURA



and Smokestacks
HARMONIA



Cleaner coal technology.
Just one way ecomagination is creating a better world.



imagination at work

James Cowland, 7:11 am, Fresno, California



Paisley over polka dots.

Donuts over granola.

Rt. 407 over freeway.

Fridays over Mondays.

YOUR CHOICE. YOUR CHASE.

Personalized Card Plan



Choose your pay date.

Choose your reward.

Choose to pay online.

You choose how and when you pay.

**Call 1-800-U-CHOOSE
or visit choosechase.com.**

CHASE 

Subject to credit approval. Chase credit cards are issued by Chase Bank USA, N.A. and may be serviced by its affiliates.
© 2005 JPMorgan Chase & Co.



Contents

China's Great Armada—28

FEATURES

- 2** **The Stem Cell Divide** Embryonic stem cells may someday help doctors treat ills from paralysis to diabetes. But science must contend with politics before that hope can be realized.
BY RICK WEISS PHOTOGRAPHS BY MAX AGUILERA-HELLWEG, M.D.
- 28** **China's Great Armada** Six centuries ago a towering eunuch named Zheng He commanded the Ming dynasty's fleet of immense trading vessels on expeditions ranging as far as Africa.
BY FRANK VIVIANO PHOTOGRAPHS BY MICHAEL YAMASHITA
- 54** **In Search of the Deadly Jelly** Australia's beachgoers are safer from lethal box jellyfish because of him, but researcher Jamie Seymour is no unstung hero. He has the scars to prove it.
BY JOHN L. ELIOT PHOTOGRAPHS BY PAUL A. SUTHERLAND
- 58** **Report From the Red Planet** More than a year after their predicted demise, NASA's Mars rovers Spirit and Opportunity keep going, and going. . . .
BY CHARLES W. PETIT
- 78** **Bitter Days for Chechnya** The mountains of the Caucasus separate Europe from Asia. Religion, politics—and a decade of war—separate the region's embattled people.
BY ANDREW MEIER
- 92** **Tapping the Rockies** Demand for natural gas and the resulting land-use pressures are pitting America's Old West against the New.
BY JOHN G. MITCHELL PHOTOGRAPHS BY JOEL SARTORE
- 114** **ZipUSA: 20812** Though its amusement park is long gone, Glen Echo, Maryland, has kept its sense of fun—and its carousel too.
TEXT AND ART BY CAROL BARTON PHOTOGRAPHS BY MICHAEL BROWN

DEPARTMENTS

From the Editor
OnScreen & Online
Behind the Scenes
Visions of Earth
Forum
Geographica
My Seven
On Assignment
Who Knew?

Final Edit
Do It Yourself
Flashback

THE COVER

Dyed stem cells cluster on a laboratory culture dish.

BY MAX AGUILERA-HELLWEG, M.D.

© Cover printed on recycled-content paper

ON THE WEBSITE

nationalgeographic.com/magazine

SIGHTS & SOUNDS Joel

Sartore is on tap.

MARS ROVER Get a 360-degree view of the planet.

ZIPUSA ART Create pop-ups.

FORUM What do you think about stem cell research?

For Membership Services:
ngmservice.com 1-800-NGS-LINE

BREAKING THE CYCLE OF AN ANCIENT SCOURGE

GlaxoSmithKline Helps Eliminate Elephantiasis by Stopping Transmission of the Disease



A Tanzanian girl suffering from lymphatic filariasis above, while preventative treatment is distributed below.



A Global Health Problem

Spread by mosquitoes, lymphatic filariasis (known as elephantiasis) is a painful, grotesquely disfiguring disease with no cure. It affects over 120 million people in 83 countries. This disabling disease causes tremendous physical suffering and economic deprivation within communities already gripped by poverty. Over one billion people are at risk—that's one in every six people on the planet.

A Global Health Solution

GlaxoSmithKline, in partnership with the World Health Organization (WHO), is helping to break the cycle of suffering over the next 20 years. To date, over 300 million albendazole treatments have been donated by GSK to help prevent new infections. Thirty million children are now protected and, one day, many more will have the chance to live free of lymphatic filariasis forever.

good companies.
good works.


gsk GlaxoSmithKline

Do more, feel better, live longer

For additional information go to www.gsk.com/community or www.filariasis.org.



AFTER 20 YEARS OF HARD WORK WE'VE ALMOST
ELIMINATED PEDIATRIC HIV
ALMOST ISN'T GOOD ENOUGH



When we started working on HIV two decades ago, we had no idea what we were up against. Even with thousands of scientists using the world's most advanced technology, it still takes about 15 years and \$800 million



just to develop one new drug. HIV requires several. Some people say drug research is too expensive, but when you consider our astounding accomplishments with pediatric HIV, and all the children we've helped to save, it's worth it.



Today's medicines. Tomorrow's miracles.SM

 **GlaxoSmithKline**

From the Editor

A story about stem cells is a story about hope, which my dictionary tells me is “to cherish a desire.” For Dean Richardson, a former deputy sheriff in Cañon City, Colorado, hope appeared in July 2003 when doctors at Northwestern University in Chicago treated him with stem cells from his own bone marrow in an attempt to break the grip of multiple sclerosis, a



MAX AGUILERA-HELLWEG, M.D.

degenerative disease that had confined him to a wheelchair. The treatment seems to have worked. Richardson’s wheelchair is gone, along with any active signs of the disease. Similar therapies have shown promise for curing certain cancers and repairing hearts. If debilitating illness can be conquered with stem cell therapy, why is it so controversial? Isn’t it a medical miracle to be celebrated? Yes and no. Though we stand on the threshold of the realm of possibility, we are not yet inside it. The doors opened by science include one marked “Moral

Dilemma.” Many scientists believe that stem cells from human embryos offer even more hope for cures than the ones found in bone marrow—the kind that helped Dean Richardson. An editorial in the *New England Journal of Medicine* called embryonic stem cell research “the great biomedical promise of our time.” Yet to destroy embryos to create stem cell therapies is an unforgivable obstacle for many people. So ethical argument mixes with scientific process. Hope must break through the rhetoric.

My own hope, the desire I cherish, is that we can freely discuss the complex, sometimes uncomfortable, friction between science and ethics. That’s what our stem cells story is all about.

CHRIS JOHNS
Editor in Chief

DENNIS R. DIMICK, WILLIAM H. MARR
Associate Editors

ROBERT L. BOOTH
Managing Editor

SENIOR EDITORS

TIM APPENZELLER, *Science*
DON BELT, *Geography & World Affairs*
WILLIAM T. DOUTHITT, *Story Development*
JOHN A. ECHAVE, *Research Grant Projects*
KEN GEIGER, *Technology*
DAVID GRIFFIN, *Photography & Illustrations*
KAREN M. KOSTYAL, *Departments*
LISA MOORE LAROE, *Staff Writers*
VALERIE A. MAY, *New Media*
PETER MILLER, *Expeditions*
KATHY MORAN, *Natural History*
OLIVER PAYNE, *Manuscripts*
CONSTANCE H. PHELPS, *Design*
LESLEY B. ROGERS, *Research*
CHRISTOPHER P. SLOAN, *Art*

EDITORIAL

Assistant Editors: Alan Mairson, Peter L. Porteous, Jane Vessels. **Articles Editors:** Lynn Addison, Glenn Oeland, Barbara Paulsen, Jennifer Reek, Margaret G. Zackowitz. **Senior Writers:** Joel K. Bourne, Jr., John L. Eliot, Jennifer S. Holland, Cathy Newman, Tom O’Neill, Cliff Tarpy, A. R. Williams. **Writers:** Chris Carroll, Peter Gwin, Carol Kaufmann, Michael Klesius, Karen E. Lange, Cate Lineberry, Lynne Warren. **Research:** David Brindley, *Assoc. Director*; Abigail A. Tipton, *Asst. Director*; **Research Editors:** Victoria C. Ducheneaux, Alice J. Dunn, Kathy B. Maher, Mary McPeak, Heidi Schultz, David W. Wooddell, Barbara L. Wyckoff. **Senior Researchers:** Nora Gallagher, Mary Jennings, Marisa J. Larson, Elizabeth Snodgrass, Christy Ullrich. **Researchers:** Karen C. Courtneage, Emily Krieger, Nancie Majkowski, Shelley Sperry. **New Media:** Cassandra Franklin-Barbajosa, *Senior Writer*

ILLUSTRATIONS

Photography: Susan A. Smith, *Asst. Director*; **Photographers:** William Albert Allard, Jodi Cobb, Michael Nichols, Mark Thiessen. **Photo Engineering:** Lawrence B. Maurer, Joseph S. Stancampiano. **Editors:** Bert L. Fox, Todd James, Elizabeth Krist, Sarah Leen, Kurt F. Mutchler, Sadie Quarrier, Susan Welchman. **Design:** Robert Gray, David C. Whitmore, *Asst. Directors*; Elaine H. Bradley, *Designers:* Betty Clayman-DeAtley, Beth Laundon, Oliver R. Uberti. **Art:** Jeffrey L. Osborn, *Assoc. Director*; Christopher A. Klein, *Asst. Director*; Kris Hannah; Patricia B. Kellogg, *Research Editor*; Ellie Boettinger, Ann R. Perry, *Researchers*

EDITORIAL SERVICES

Administration: Marisa Domeyko, *Staff*; Carol Dumont Kerby, *Scheduling*; Maria-Teresa Lawrence, *Business Manager*; Brian E. Strauss, *Electronic Publishing*; Kristin A. Weichman, *Asst. to the Editor in Chief*; Sandra M. Dane, Luz Garcia. **Communications:** Mary Jeanne Jacobsen, *Vice President*; Barbara S. Moffet, Laura M. Reynolds. **Correspondence:** Joseph M. Blanton, Jr., *Director*; Carol Stroud, Lisa Walker. **Image Collection:** Maura A. Mulvihill, *Vice President*; William D. Perry, *Sales*; Carolyn J. Harrison, John A. Rutter. **Libraries and Information Services:** Susan Fifer Canby, *Vice President*; Renee Braden, Ellen D. Briscoe, Barbara P. Ferry, Anne Marie Houppert, Ann E. Hubbs, Karen Huffman. **Travel:** Cristine E. Ghiliani

PRODUCTION SERVICES

Hans H. Wegner, *Vice President*. **Digital Imaging:** Thomas J. Craig, *Director*; Martin G. Anderson, Clayton R. Burneston, Phillip E. Plude, Bernard G. Quarrick. **Distribution:** Michael Swarr, *Director*. **Engraving:** George Bounellis, *Director*; William D. Reicherts. **Printing:** Joseph M. Anderson, Edward J. Holland. **Quality:** Ronald E. Williamson, *Director*

MAGAZINE PUBLISHING

Advertising: Stephen P. Giannetti, *Vice President and Group Publisher*; Sean P. Flanagan, *Vice President and Worldwide Publisher*; Claudia Malley, *Vice President and U.S. Publisher*. **Directors:** John G. Huber, *Integrated Marketing*; Ron Bottorff, *Western Sales*; Margaret Robertson, *Business and Operations*; Suzanne Samour, *Marketing*. **Regional Managers:** Bob Amberg, *Southeast*; John Iavarone, *Detroit*; John Patten, *Eastern*. **Circulation:** Terry Day, *Vice President*. **Directors:** Elizabeth M. Safford, *North America*; John A. Seeley, *International*. **Member Services:** Christina C. Alberghini, *Director*

EVERY 2005 FORD EXPLORER IS EQUIPPED WITH NEW ROLL STABILITY CONTROL.[™]

Inside every 2005 Ford Explorer is a gyrochip sensor that constantly monitors vehicle motion. It's there to help keep all four wheels firmly planted. RSC* is an amazing new technology. And Explorer is the only SUV that has it.** At Ford, we're always thinking of ways to help make you safer. For more information, visit fordvehicles.com or call 1-800-301-7430.



EXPLORER
Built for the road ahead.

*AdvanceTrac[®] with Roll Stability Control.[™] **Excludes other Ford products.

OnScreen & Online



NATIONAL GEOGRAPHIC
CHANNEL



WEDNESDAYS AT 9 P.M. ET/PT

MegaStructures Climb the peaks of the world's most impressive buildings and see what it took to build the record-setting Petronas Towers (above) in Kuala Lumpur, Malaysia. *MegaStructures* presents dizzying tales of bold engineering and design.

SUNDAYS AT 8 P.M. ET/PT

EXPLORER Experience the most riveting stories of our time on National Geographic Channel's documentary series *Explorer*. With host Lisa Ling, you'll travel to the front lines of exploration and adventure, culture and politics, science and natural history. This month find out why wild elephants in Africa and India are now more feared than even lions and tigers. Tune in to *Explorer* for this and other exciting investigations.

nationalgeographic.com

VISIONS OF EARTH See more photos like this month's Visions of Earth, taken by Bill Atkinson. View the images in an online photo gallery and learn how he got the shots.

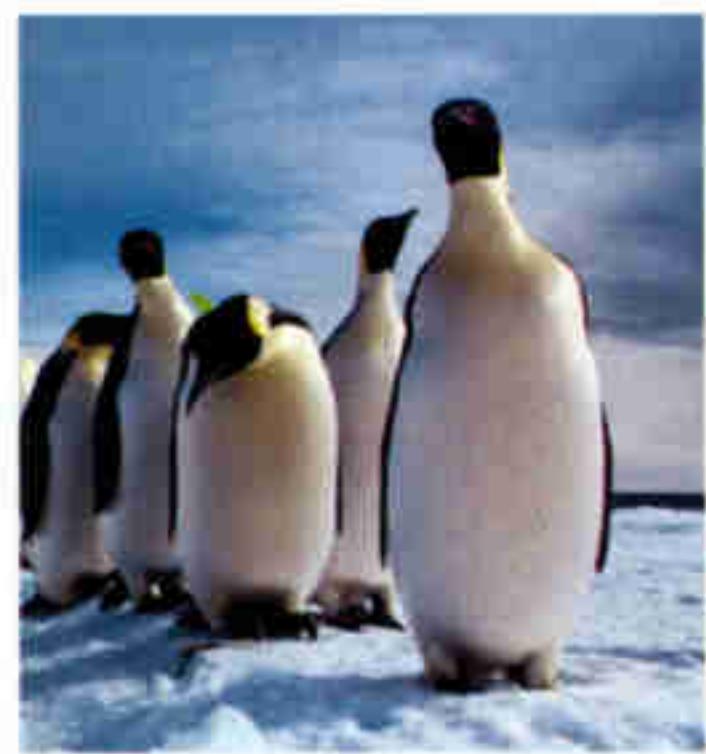
■ **INTERVIEW** Find out what inspires Atkinson, a computer guru turned nature photographer, at nationalgeographic.com/magazine/0507.

EMERGING EXPLORERS Explore the heights of the Inca Empire. Perhaps the only thing more impressive than archaeologist Constanza Ceruti's high-altitude feats is that the Inca accomplished them 500 years ago. ■ **CLIMB ON** Join Ceruti's search for Inca mummies and more at nationalgeographic.com/emerging.

IN THEATERS NOW

March of the Penguins

Witness one of nature's most compelling survival stories: the quest of emperor penguins to reproduce in Antarctica, one of the world's harshest environments. This new feature film by Luc Jacquet follows a pair of emperors as they proceed from courtship to parenthood. You'll see the father incubate their single egg and watch the mother dodge predators on her harrowing hunt for food.



Find out what's on and how to get the Channel in your area at nationalgeographic.com/channel. Programming information accurate at press time. Consult local listings.

Purchase National Geographic DVDs at shopngvideos.com or call 1-800-627-5162.

PHOTO OF THE DAY

Get your photo fix. There's a new picture every day at nationalgeographic.com/photography/today.

PHOTOGRAPHY

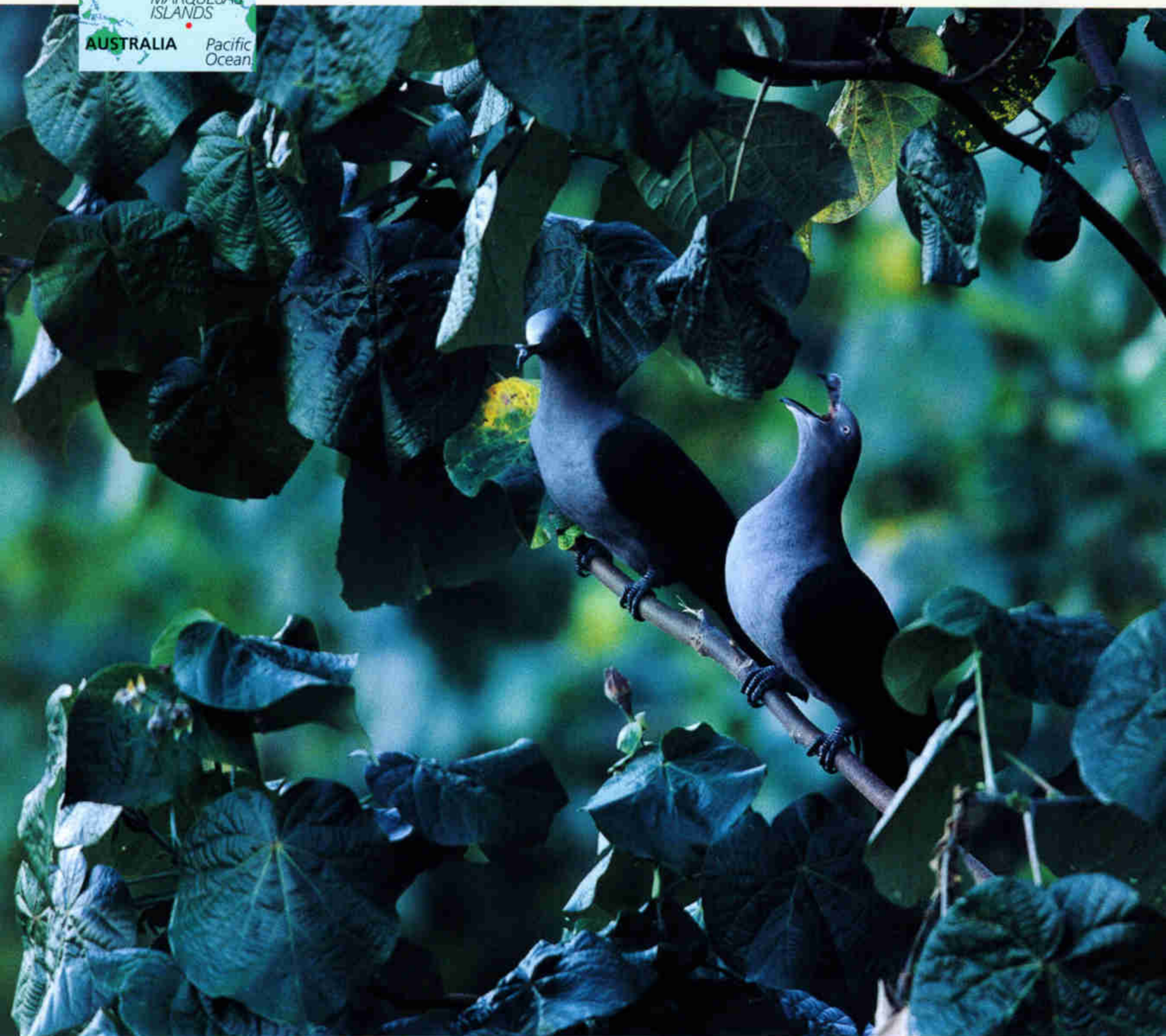
Find Web-exclusive photo galleries, tips from our photographers, desktop wallpaper, and Sights & Sounds multimedia features that reveal how our photographers got the story. nationalgeographic.com/magazine



Marquesan Imperial-pigeon (*Ducula Galeata*)

Size: Length, 53-56 cm **Weight:** 500-590 g **Habitat:** Restricted to mature forest of Nuku Hiva and Ua Huka in the Marquesas Islands of French Polynesia

Surviving number: Estimated at 100-250



Photographed by Tim Laman

WILDLIFE AS CANON SEES IT

Neighborhoods matter. The Marquesan imperial-pigeon has found a very fortunate one: forest patches and remote valley bottoms between volcanic ridges. This home is inaccessible enough that poachers and introduced grazers have rarely made an appearance—yet. The elusive bird has been a boon to its location, too: the tireless fruit-eater swallows seeds whole and disperses them throughout the area. But the pigeon is obliged to

leave its stronghold to forage for food. And while it once had a presence on four island chains, its range has dwindled to a precarious 32 square kilometers. A few new roads and there goes the neighborhood.

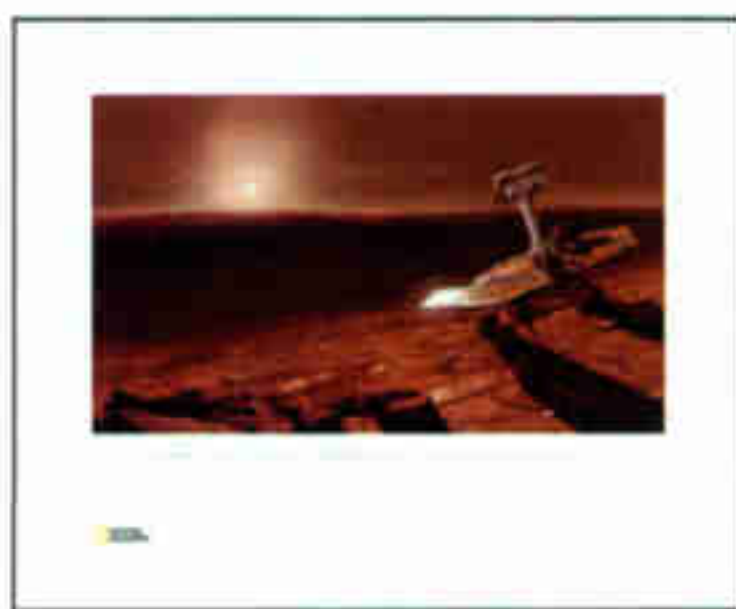
As an active, committed global corporation, we join worldwide efforts to promote awareness of endangered species. Just one way we are working to make the world a better place—today and tomorrow.

Behind the Scenes

EXHIBIT

Tut's Return

National Geographic—with support from AEG Exhibitions as well as Arts and Exhibitions International—is bringing the glory of ancient Egypt to the United States. Items from King Tutankhamun's tomb (including this sculpture, right) and other treasures will tour the country. Also featured in the show: information gleaned from Tut's CT scan. "I doubt there'll ever be an exhibit like it," says Terry Garcia, National Geographic executive vice president. Zahi Hawass, head of Egypt's Supreme Council of Antiquities, has authored *Tutankhamun and the Golden Age of the Pharaohs* to accompany the exhibit, which opens June 16 at the Los Angeles County Museum of Art. For tickets and information go to kingtut.org or call 1-877-TUT-TKTS.



SPECIAL EDITION PRINT OFFER

Red Rover Our latest print shows NASA's Mars robot explorer Opportunity perched near the edge of Endurance crater, catching the day's last rays on its solar panels. Opportunity and its twin rover, Spirit—far outlasting their original life spans—have roamed the red planet tracking signs of ancient water.

The print is available for \$29.95 plus \$6.95 for shipping (\$9.95 for international orders). We will produce only as many 24-by-20-inch prints as we receive orders for by midnight on August 31, 2005. Each will be hand-numbered and embossed with the Society seal. Shipping is scheduled for October 2005. Please add appropriate sales tax for orders sent to CA, DC, FL, KY, MI, PA, VA, VT, and Canada. Call toll-free: 1-800-621-0723 (outside the U.S. and Canada call 1-813-979-6845). You may also order online at nationalgeographic.com/magazine or by mail to PO Box 63035, Tampa, FL 33663-0035.

CHINA'S GREAT ARMADA (PAGE 28)

Get More

To learn more about a subject covered in this issue, try these National Geographic Society products and services. Call 1-888-225-5647 or log on to nationalgeographic.com for more information. ■ **Charting China's Past**, a trip offered by National Geographic Expeditions, explores China's rich history on a 17-day journey from Beijing to Shanghai. Cruise down the Yangtze River, visit the Forbidden City in Beijing, and walk along the Great Wall. Expeditions depart October 11 and October 18. Call 1-888-966-8687 for more information. ■ **Asia Political Map** Trace voyages of Admiral Zheng He from China to Southeast Asia and across the Indian Ocean. Map measures 38 by 34 inches (\$14.99).

Calendar

JUNE

"Surviving Darfur" exhibit featuring photographs of refugee life in Chad and Sudan continues through July 17 as part of United Nations World Refugee Day events. National Geographic Museum, Washington, D.C.

JULY

8 March of the Penguins opens in wide release in U.S. theaters from National Geographic Feature Films and Warner Independent Pictures. The movie tells the story of Antarctica's emperor penguins as they migrate to distant mating grounds, raise chicks, and fight for survival.

10 National Geographic World Championship

Geography competition winners from more than 20 countries compete in the ultimate geography test. July 10-15, Budapest, Hungary.

AUGUST

15 "Africa Megaflyover" exhibit opens. Learn about explorer Mike Fay's aerial survey of Africa, and see images from the epic journey. National Geographic, Washington, D.C.

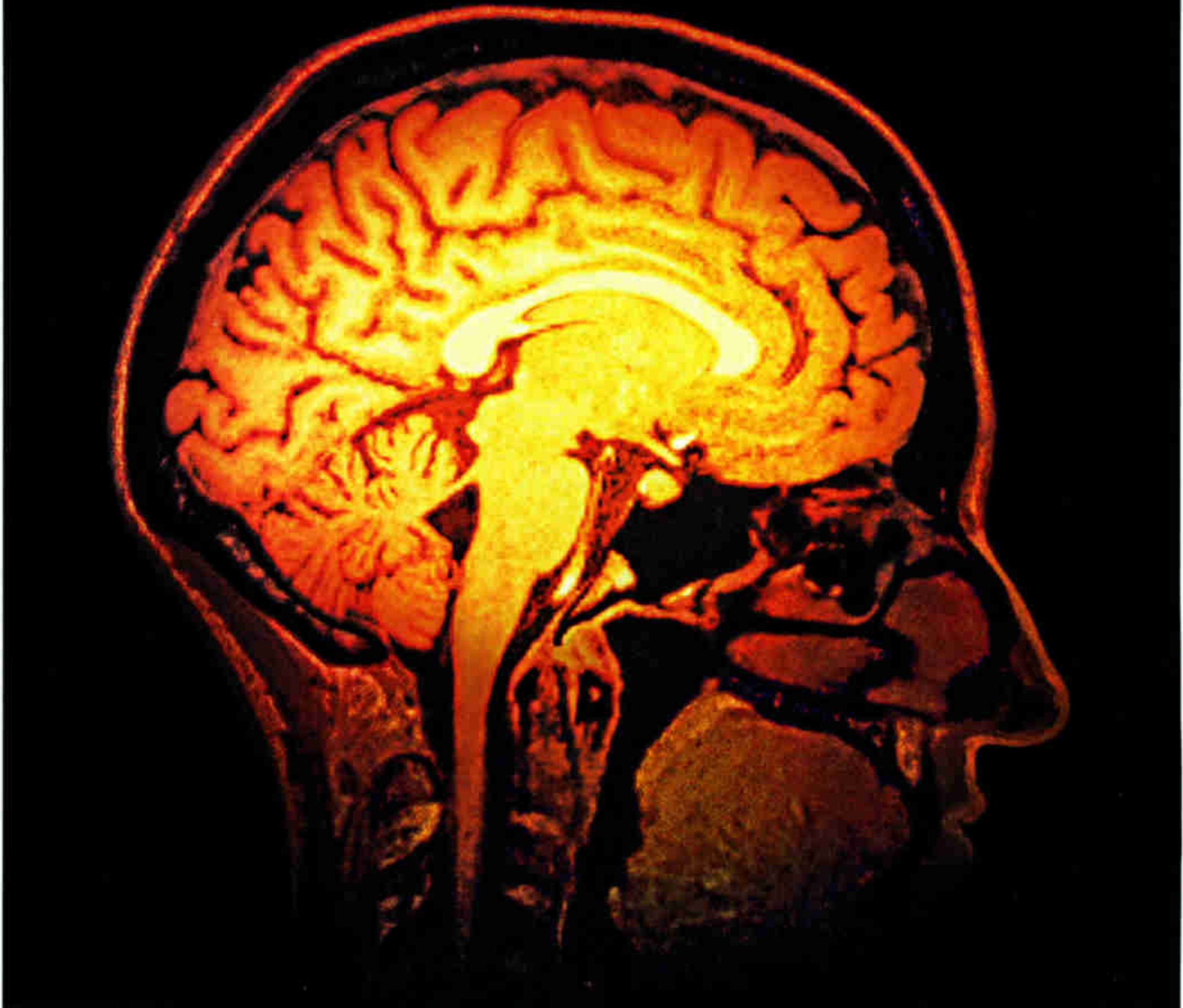
SEPTEMBER

22 All Roads Film Festival

Enjoy the work of an international group of culturally diverse filmmakers, photographers, and artists. September 22-25, Egyptian Theatre, Los Angeles.

Calendar dates are accurate at press time; please go to nationalgeographic.com or call 1-800-NGS-LINE (647-5463) for more information.

More energy and lower emissions?
Only one kind of power can deliver them both.



That's why, for decades, ExxonMobil has consistently led the energy industry in research and technology. And why we're now making the largest ever investment in independent climate and energy research that is specifically designed to look for new breakthrough technologies. exxonmobil.com

ExxonMobil
Taking on the world's toughest energy challenges.™

THROUGH A PHOTOGRAPHER'S EYE

Visions of Earth





KUNENE REGION, NAMIBIA

Secret worlds, secret designs—

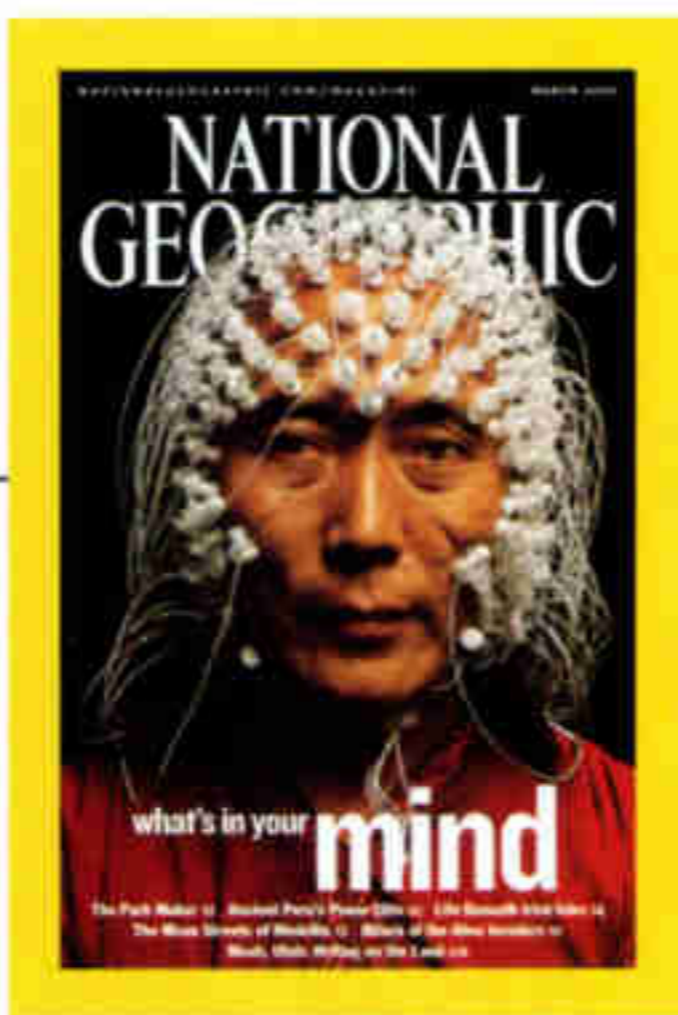
that's what I try to capture with my camera. I've found that nature works with a limited set of patterns, but they create nearly unlimited forms at different scales. The results, whether seen from space or under a microscope, evoke powerful responses. In this image I see a waterfall; for other people, it's a landscape from a dream. When they learn it's a polished, inch-and-a-half slice of a rock called pietersite, they're stunned. —Bill Atkinson

► Explore an online gallery of mesmerizing images and find out more about the photographer in an Online Extra at nationalgeographic.com/magazine/0507.

Forum

March 2005

"Beyond the Brain" and "Alien Invaders" generated the greatest number of letters this month, but the story on Medellín sparked your most passionate responses. We also continue to hear from readers about a story in the November issue—"Was Darwin Wrong?" The debate among you about the answer to that question goes on.



Alien Invaders

If there were a contest for the most prolific, pervasive, and devastating invasive species ever, humans would take first place. We invade forests, cut and burn the native trees, and replace them with our farms. We invade the desert, irrigate it, and erect our cities, then we multiply and pollute. Before we set out to solve the predicament of the zebra mussels, brown tree snakes, or fire ants, how about tackling the ultimate problem of human overpopulation?

VU MINH LY

Mira Mesa, California

FROM OUR ONLINE FORUM

nationalgeographic.com/magazine/0503

One person's trash is another person's treasure. It's interesting that brown and rainbow trout were on the 100 least wanted list. Here in California the Department of Fish and Game

has spent millions to raise rainbow and other native trout species. They are stocked in lakes and streams where thousands of fishermen enjoy catching them. If you don't want your trout, send them to us; we'll pay you for the sheer pleasure of releasing them and then trying to catch them again.

STEVE ROBERTS

San Clemente, California

There appears to be a warm-blooded bias in invasive species management in Florida. I can agree with euthanizing Nile monitors and Burmese pythons that are found in the wild. But I find it inconceivable that people actually release neutered feral cats back into the wild if they aren't adopted.

DAVID SMITH

Flagstaff, Arizona

What's the big deal about alien plants and animals the world over? *Homo sapiens* is a species that has spread like a cancer throughout the world, causing the extinction of millions of other native species. Why should other "invasive species" not get an equal opportunity at colonizing and destroying the planet?

ROB HAFER

Edmonton, Alberta

FOR MORE INFORMATION

To get NATIONAL GEOGRAPHIC please call 1-800-NGS-LINE (1-800-647-5463). Hearing-impaired TDD users may call 1-800-548-9797.

The magazine's website: nationalgeographic.com/magazine

For an online index of all National Geographic publications, go to:

nationalgeographic.com/publications



NATIONAL GEOGRAPHIC SOCIETY

"For the increase and diffusion of geographic knowledge."

The National Geographic Society is chartered in Washington, D.C., as a nonprofit scientific and educational organization. Since 1888 the Society has supported more than 7,500 explorations and research projects, adding to knowledge of earth, sea, and sky.

JOHN M. FAHEY, JR., *President and CEO*

Executive Vice Presidents

TERRENCE B. ADAMSON

LINDA BERKELEY, *President, Enterprises*

TERRY D. GARCIA, *Mission Programs*

JOHN Q. GRIFFIN, *President, Magazine Group*

NINA D. HOFFMAN, *President, Books and*

School Publishing Group

CHRISTOPHER A. LIEDEL, *CFO*

BOARD OF TRUSTEES

GILBERT M. GROSVENOR, *Chairman*

REG MURPHY, *Vice Chairman*

JOAN ABRAHAMSON, MICHAEL R. BONSIGNORE,

MARTHA E. CHURCH, MICHAEL COLLINS,

ROGER A. ENRICO, JOHN M. FAHEY, JR., DANIEL S.

GOLDIN, JOHN JAY ISELIN, JAMES C. KAUTZ,

J. WILLARD MARRIOTT, JR., FLORETTA DUKES

McKENZIE, GEORGE MUÑOZ, PATRICK F.

NOONAN, NATHANIEL P. REED, WILLIAM K.

REILLY, ROZANNE L. RIDGWAY, JAMES R. SASSER,

B. FRANCIS SAUL II, GERD SCHULTE-HILLEN

TRUSTEES EMERITUS

Joe L. Albritton, William L. Allen, Thomas E. Bolger, Frank Borman, Lewis M. Branscomb, Robert L. Breeden, Lloyd H. Elliott, George M. Elsey, Mrs. Lyndon B. Johnson, Robert C. Seamans, Jr.

COUNCIL OF ADVISORS

Roger A. Enrico, *Chairman*; Michael R. Bonsignore, Howard G. Buffett, Craig D. Campbell, Jean N. Case, Juliet C. Folger, Robert B. Haas, Robert A. Hefner III, David H. Koch, Bruce L. Ludwig, Sally Engelhard Pingree, W. Russell Ramsey, Catherine B. Reynolds, Edward P. Roski, Jr., B. Francis Saul II, Michele Sofisti, Ted Waitt, Garry A. Weber, Tracy R. Woistencroft

RESEARCH AND EXPLORATION COMMITTEE

Peter H. Raven, *Chairman*; John M. Francis, *Vice Chairman*; Martha E. Church, Steven M. Colman, Scott V. Edwards, William L. Graf, Nancy Knowlton, Dan M. Martin, Scott E. Miller, Jan Nijman, Stuart L. Pimm, Elsa M. Redmond, Bruce D. Smith, Hans-Dieter Sues, Patricia C. Wright, Melinda A. Zeder

EXPLORERS-IN-RESIDENCE

Robert Ballard, Wade Davis, Sylvia Earle, Zahi Hawass, Louise Leakey, Meave Leakey, Johan Reinhard, Paul Sereno, Spencer Wells. **Conservation Fellow:** J. Michael Fay

MISSION PROGRAMS

Vice Presidents: Barbara A. Chow, *Education Foundation*; John M. Francis, *Research, Conservation, and Exploration*; Jacqueline M. Hollister, *Development*; Sarah Laskin, *Public Programs*. **Exhibits:** Susan S. Norton. **Expeditions Council:** Rebecca Martin. **Geography Bee:** Mary Lee Elden. **Lectures:** P. Andrew van Duym, Gregory A. McGruder

School Publishing: Ericka Markman, *Sr. Vice President*

International: Robert W. Hernández, *Sr. Vice President*

Human Resources: Thomas A. Sabló, *Sr. Vice President*

Communications: Betty Hudson, *Sr. Vice President*

Treasurer: H. Gregory Platts, *Sr. Vice President*

NATIONAL GEOGRAPHIC VENTURES

DENNIS R. PATRICK, *Chairman and CEO*

Timothy T. Kelly, *President*; Edward M. Prince, Jr., *COO*

National Geographic Channel: David Haslingden, *President, International*; Lauren Ong, *President, U.S.*

Digital Media: Chris McAndrews, *President*

National Geographic Maps: Frances A. Marshall, *President*; Allen Carroll, *Chief Cartographer*

Television: Michael Rosenfeld, *Executive Vice President*

Contributions to the National Geographic Society are tax deductible under Section 501(c)(3) of the U.S. tax code.

Copyright © 2005 National Geographic Society. All rights reserved. National Geographic and Yellow Border: Registered Trademarks © Marcas Registradas. National Geographic assumes no responsibility for unsolicited materials. Printed in U.S.A.



Your time becomes real-time

Life's Good when you have the power to control time. With one touch of the DVR (Digital Video Recorder) button, LG Plasma TV can 'Time Shift' your favorite live match and let you watch it anytime you choose. Whether you're taking a short snooze at halftime or attending to more important matters, now your favorite players can be on your time!



Beyond the Brain

Never before has a magazine struck me in a way the March issue did. I am an almost seven-year survivor of a brain tumor resection. I found your article an informative and accurate portrait of the complex interaction between ourselves and our brains, as well as the state of medicine in this area. The pace of development is incredible!

WALTER DUNCAN
Strasburg, Ohio

I was disappointed by "What's in Your Mind." With a few key-strokes, the author abolished the human spirit. It is hardly possible that the great civilizations that your publication explores were created by firing synapses, or that these motivate

our quest for the stars. I invite James Shreeve to attend a symphony or visit our own country's national monuments and then revisit his belief that the mind is what the brain does.

HELGI RUENNE
Clearwater, Florida

I think you showed extremely poor taste in photographing an infant with a python. Even if the baby was too young to be afraid, it was still a disturbing picture. There are other ways to convey the point about learned fear than to place a naked child in the coils of a snake. For your next photograph, why not just throw a baby into a lion's den?

REBECCA ROWAN
Culpeper, Virginia



CARY WOLINSKY

Ollie, an olive python, is a fully habituated snake that has been raised by its owner Rex Neindorf since it was an egg. Ollie is around children practically every day. In fact, his day job is to visit children in classrooms in Alice Springs, Australia, to help them understand that there are snakes that will not hurt them. The mother of the child in the photograph (above) has known Rex—and Ollie—for many years, and she was present when the photo was taken.

Wow, look what happens when you put patients first.

Preventing disease.

Thanks to Merck scientists, many childhood diseases are uncommon today. Merck is one of the few drug companies still working to develop new vaccines. One day, vaccines may be able to prevent tough diseases like cancer.

Your article on invasive species was superb. There are many more invasive species that should be on the hit list. One in particular is the oriental ladybug. These despicable varmints have multiplied to such a degree that their bad points far outweigh their good points.

PAUL HOSKINS
Walton, Kentucky

Many other readers also wrote to add invasive species to the least wanted list. Here are some of your additions: the Canada goose, Indian stick insect, Eurasian water milfoil, yellow star thistle, and Chinese tallow tree.

Medellín's Mean Streets

It is with great frustration that I read your article. Starting with the title, "Medellín: Stories From an Urban War," and going

through the "characters," the article is filled with old data and imprecise references that say nothing about the actual situation in Medellín. For a long period of time we have had to struggle with the label of the most violent city in the world, the city of the cartels. It is true that we had to face the narco-business, an unpredictable phenomenon no one could have ever foreseen. But we dealt with it and still do, just like the rest of the country, and like the consumer countries do. For the record, violence rates have been decreasing, and now we have the average number for a Latin American city; the year 2004 was the least in two decades. We lowered our homicide rate per 100,000 inhabitants to 57. We are working with the public schools of the area to improve

the quality of education, and we're creating new public spaces to promote the development of open, alive, and peaceful neighborhoods. We are working to promote enterprise creation among the less fortunate people. I urge you and your team to visit Medellín to witness what really is going on in our neighborhoods and streets and to acknowledge how we are working with and for the people and creating better living conditions for all. We deserve the opportunity

WRITE TO FORUM National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199, or by fax to 202-828-5460, or via the Internet to ngsforum@nationalgeographic.com. Include name, address, and daytime telephone. Letters may be edited for clarity and length.

Fighting disease.

Merck has invested billions to research heart disease, asthma, cholesterol and blood pressure. And now we're trying to make Alzheimer's, diabetes and cancer history too.

Providing information.

The *Merck Manual* is the world's best-selling health guide. It's free online at merck.com. For more information on Merck, call 1-800-9MERCCK7.

Where patients come first  **MERCK**

to show the world what Medellín really stands for.

SERGIO FAJARDO VALDERRAMA
Mayor
Medellin, Colombia

The Editor replies: I appreciate the concerns described in your letter. I am delighted to hear that your city's murder rate has continued to decline, confirming the trend mentioned in our article on page 82. I assure you that NATIONAL GEOGRAPHIC approached the story on Medellín with thoughtfulness and objectivity. Our journalistic standards are second to none, and what we found on the streets of Medellín was reported fairly and accurately. Our author and photographer both have long experience in Colombia and spent months in the field recently to research and prepare this article. The overall balance and theme of the piece was reviewed by a number of experts, both inside and outside of Colombia. They found that our story was, in fact, an accurate portrayal of everyday life in the barrios of your city. I humbly suggest that, rather than disparaging your city, our portrayal of the paisas actually embodies the spirit of renewal and hope that you so eloquently describe in your letter and nurture through your public initiatives.

CHRIS JOHNS
Editor in Chief

Underwater Ireland

What a revelation to discover that such beauty lies beneath our waters—something I would only have associated with tropical islands.

JOHN QUINN
Clarinbridge, County Galway

The Park Maker

How delightful to see a reference to Birkenhead Park in England as the inspiration for Frederick

Law Olmsted's design of New York's Central Park. Today it would be hard to imagine that my small, sleepy hometown of Birkenhead could have such an illustrious offspring.

JIM GODDARD
Shipley, West Yorkshire

Judith Steinbergh offers us not only the spectacle of Moab but also the resplendence of the language of plant, of rock, of history. The sumptuous words stand as tall and strong as the rocks themselves.

I work in Trenton, New Jersey, and have long known that the city's Cadwalader Park was designed by Frederick Law Olmsted. It celebrated its centennial in 2002. I was dismayed that this park did not make your list of Olmsted creations.

CARL H. DOAN
Medford, New Jersey

Many readers wrote to acknowledge their favorite Frederick Law Olmsted creation. In his lifetime Olmsted worked on hundreds of projects, including parks, gardens, colleges, and private estates. Since we couldn't include all of them, we decided to highlight his most prominent works.

ZipUSA: Moab, Utah

Judith Steinbergh offers us not only the spectacle of Moab but also the resplendence of the language of plant, of rock, of history. The sumptuous words stand as tall and strong as the rocks themselves and pull us in to feel part of the "red-rock wilderness." Thank you for helping all of us understand how poetry can allow us to see the world in fresh ways.

JANET DAVIS KARMAN
Southborough, Massachusetts

While the poetry and photos in ZipUSA 84532 paint a lovely picture of the southern Utah desert, I find the author and photographer romanticize life in Moab and ultimately do a disservice to our community. As a resident for nearly 14 years, I have experienced the good, the bad, and the ugly of our little town. If you are a tourist or a journalist coming to the area, it is easy to miss the fact that more than 30 percent of our residents live below the poverty level, we have some of the highest alcohol and drug abuse rates in the state, and our town boasts a vast uranium tailings pile.

ALISON KENNEDY
Moab, Utah

Geographica: Weeding Out Land Mines

It seems like a great idea: growing a plant that can help us detect land mines. But isn't this how many of the invasive species cited later in the same issue got their start?

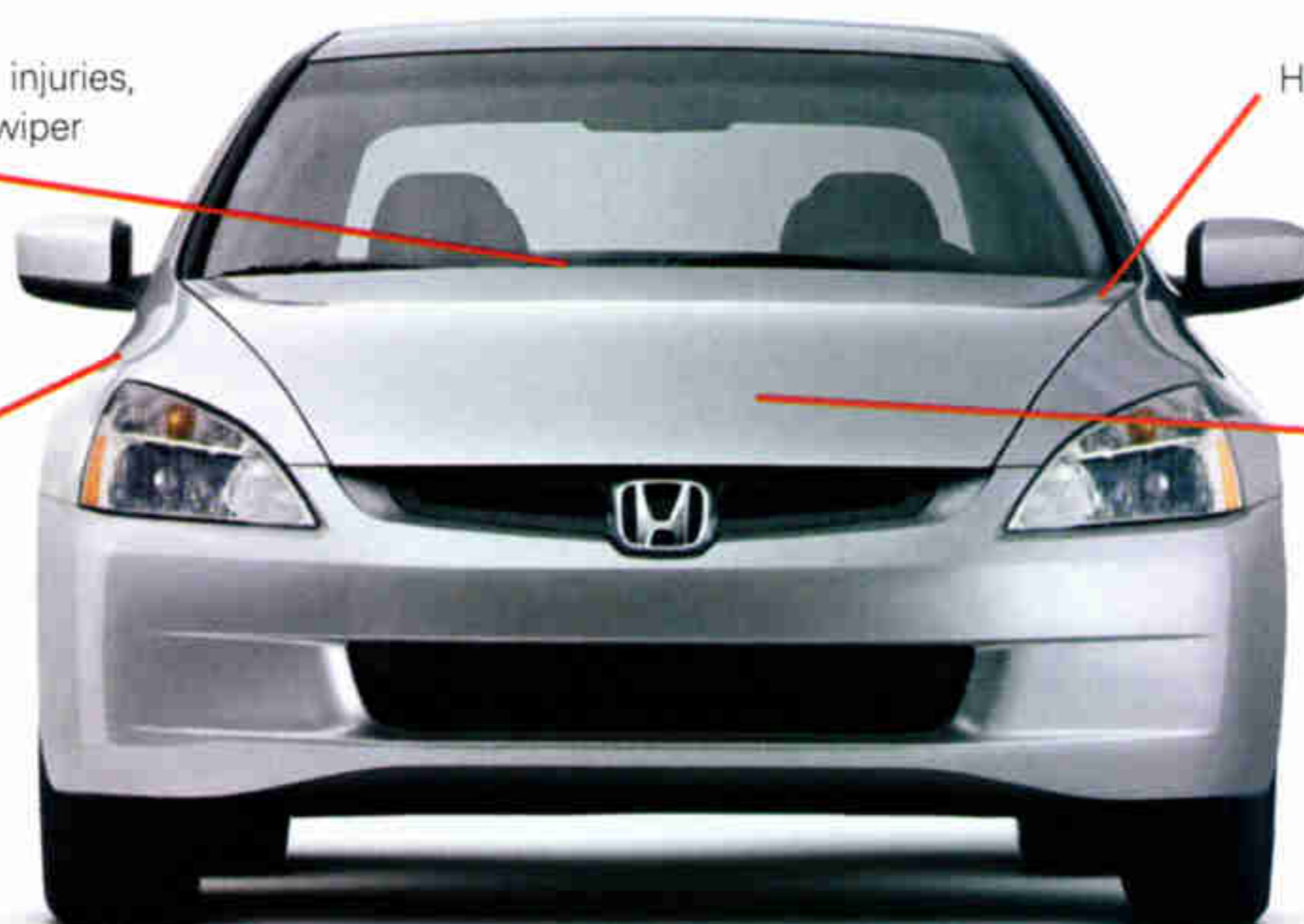
ERIC CALVERT
Ottawa, Ontario

We occasionally make our customer list available to carefully screened companies whose products or services may be of interest to you. If you prefer not to receive such mailings, U.S. and Canadian customers please call 1-800-NGS-LINE (1-800-647-5463). International customers please call +1-813-979-6845 or write: National Geographic Society, P.O. Box 63005, Tampa, FL 33663-3005. Please include the address area from your magazine wrapper when writing.

Every car company is concerned about the people inside its cars. But what about the people outside?

To help reduce pedestrian injuries, the modified windshield-wiper system helps absorb energy in the event of an accident.

The energy-absorbing space under the front fenders is designed to minimize injury.



Honda redesigned the hood hinge so it bends with the force of an impact to help minimize pedestrian injuries.

The specially designed hood creates a space between the engine and the hood to lessen the severity of an impact.

As part of Honda's commitment to "Safety for Everyone," we are leading the industry in technology to help protect pedestrians in the event of an accident. Approximately 70,000

pedestrians a year are involved in traffic crashes. And about 5,000 of these end in fatalities. In our efforts to help reduce injuries, especially to the head, Honda created POLAR II, a unique pedestrian test dummy with sensors that help analyze the types of injuries that could be sustained



Created by Honda engineers, POLAR II is the most advanced pedestrian test dummy, and simulates the kinematics of the human body.

in an accident. Our pioneering research has led to the development of a number of pedestrian-protection features, including injury-reducing designs that minimize direct contact with the most rigid part of the vehicle. More than 2 million U.S. Honda and Acura vehicles on the road today have this equipment. Honda is firmly committed to advancing our safety technologies, with our goal of "Safety for Everyone" leading the way.



POLAR II has instruments that measure the level of injury throughout the body, including the head, neck, chest, abdomen and legs.

HONDA
The Power of Dreams

G E O G R

T H E P E O P L E , P L A C E S , A N D

CLIMATE

Nary a Drop to Spare

Drought grips the West

Three generations of the Messner family have farmed the land near Twin Falls, Idaho, but none had ever seen it get this dry. It's worse even



Growing Thirst

Population growth is exploding in western states. The driest of all, Nevada, leads the way with a 66 percent increase from 1990 to 2000.

than during the Dust Bowl years of the 1930s. "In the 80-plus-year history of the canal company that supplies us water, we've never had more than two extremely dry years in a row," says Everett Messner, 53, whose farmland requires extensive irrigation. "Now we've had five."

From north to south, the western United States is reeling from a tenacious five-year drought. And although a wet fall and spring rains have brought some relief to sections of the Southwest, the drought is far from over, says

Fresno County, California, withdrew 3.7 billion gallons of fresh water a day in 2000, more than any other U.S. county.

Farming's Big Draw

Without billions of gallons a day to irrigate places like California's Central Valley, the supply of fruits and vegetables stocking U.S. grocery stores would wither.

APHICA

CREATURES OF OUR UNIVERSE

Urban Drain In eastern metropolitan areas, water consumption—for manufacturing, drinking, cleaning, flushing, and sprinkling—rivals that of farmers in the West.

Parched Earth Five years into a severe drought, there's not enough water to meet the diverse needs in the western United States. Farmers are leaving dry fields fallow, cities are imposing water-use restrictions on residents, and hydroelectric plants are scaling back power production.

Drought condition, early fall 2004
(prior to October rains)

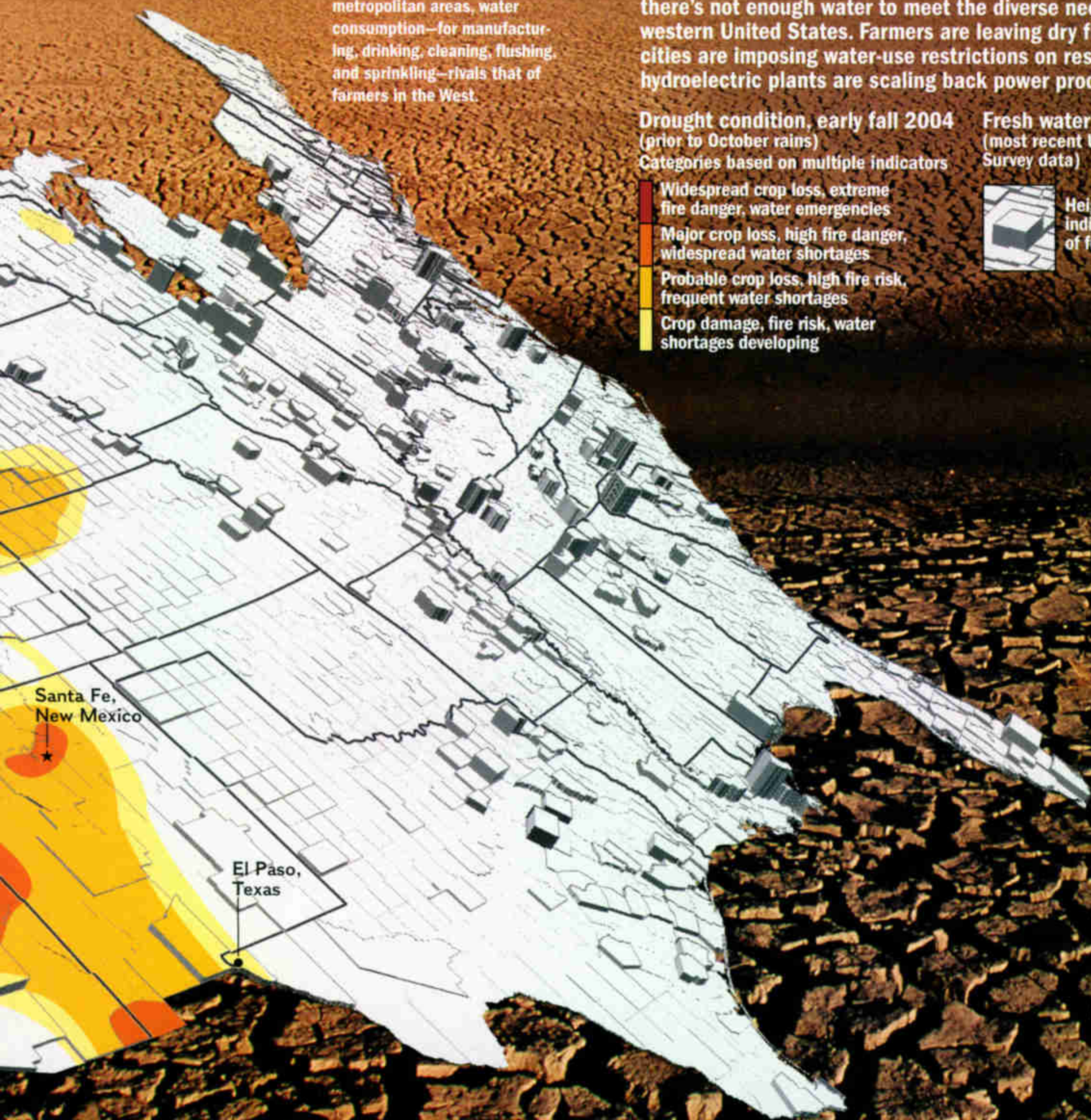
Categories based on multiple indicators

- Widespread crop loss, extreme fire danger, water emergencies
- Major crop loss, high fire danger, widespread water shortages
- Probable crop loss, high fire risk, frequent water shortages
- Crop damage, fire risk, water shortages developing

Fresh water use, 2000
(most recent U.S. Geological Survey data)



Height of county indicates volume of fresh water use.



Mark Svoboda, a climatologist with the National Drought Mitigation Center. Major southwestern reservoirs like Lakes Powell and Mead will probably need several years of normal rainfall before they refill. In the Northwest the short-term forecast calls for more dry weather. And several long-term trends suggest the West may have a long, dry road ahead.

One of those trends is global warming. Higher temperatures affect water supply by raising the snow line in mountainous areas. Instead of precipitation being stored as snow that melts gradually during the summer for use by farmers, cities, and hydroelectric utilities, the moisture runs off uselessly in the winter. Why not catch that runoff in reservoirs? Water managers fear overflowing during the winter could result in potentially dangerous floods when snowpacks melt in the spring.

Another challenge is the byzantine maze of state and federal laws and treaties that govern water rights. Farmers—who are the West's biggest water consumers—use tens of billions of gallons each day to irrigate millions of acres of arid cropland. As the water supply has run short, so have tempers.

In Idaho earlier this year, a water war erupted, pitting farmers who use the Snake River for irrigation against those who pump water from the massive East Snake River aquifer. These water bodies are connected, so depleting one means depleting the other. Under Idaho law, those who hold the oldest water permits have first right to tap local water supplies. River users—whose permits generally pre-date those held by groundwater users—have demanded the state government prohibit further



JIM WARK, AIRPHOTO

pumping from the aquifer. “There’s an old Western saying,” observes Michael Keckler of the Idaho Department of Water Resources, “Whiskey’s for drinking and water’s for fighting over.”

Dramatic population growth in the West could also exacerbate long-term water shortages. In Colorado, where the population surged 31 percent from 1990 to 2000, the impacts are easy to see: A reservoir in suburban Denver, drawn down during the fall of 2004, visibly shrank (above).

As pressure increases on the water supply, so does the probability of future conflict, says Kelly Redmond, a NOAA climatologist at the Desert Research Institute. “We’re getting closer to the edge, where there’s less room to maneuver,” he says.

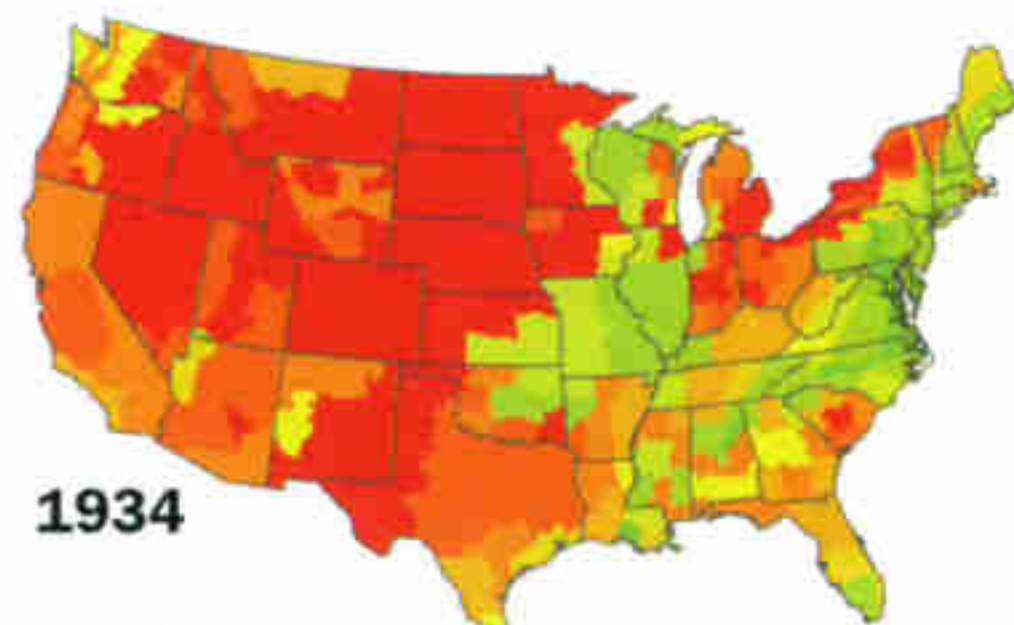
Idaho farmer Everett Messner has already lost most of his wiggle room. With local reservoirs running so low, he can’t plant late-season crops like beans or corn this year. “Pretty much by July, our water will be done.”

—Chris Carroll

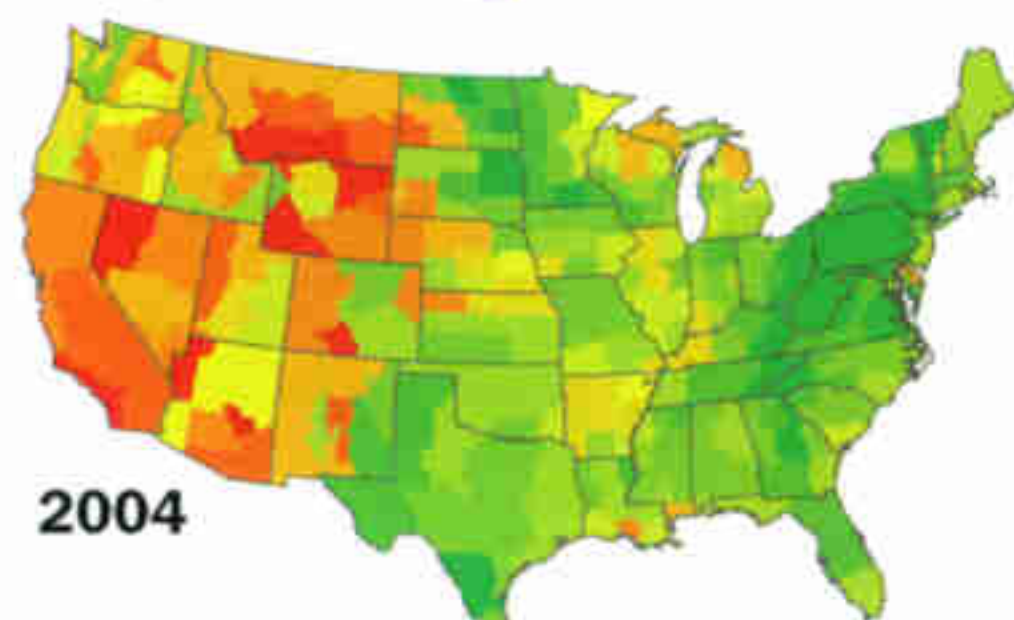
WEBSITE EXCLUSIVE Find links and resources selected by our Research Division, in Departments at nationalgeographic.com/magazine/0507.

Defining a Drought

According to the Palmer Drought Severity Index (PDSI), which measures temperature, rainfall, and soil moisture, the 1930s Dust Bowl (below) was far worse than the current drought (bottom). But the PDSI and other climatic indexes don’t capture a key variable: the growing demand for water. “I tend toward a definition of drought that takes demand as well as supply into account,” says climatologist Kelly Redmond. “To put it simply, a drought is when there’s not enough water to meet needs.”



1934



2004

Palmer Drought Severity Index

Extreme drought Near normal Extremely wet

SOURCE: NOAA NATIONAL CLIMATIC DATA CENTER
NG MAPS



**JOB DESCRIPTION:
SAVE THE PLANET.**

Dr. Sylvia Earle's office covers two thirds of the Earth's surface. Her job title is a little more difficult to define. Marine biologist. Oceanographer. Botanist. Aquanaut. Explorer. And innovator. Above water, Dr. Earle has spent more than 40 years working to preserve the oceans. Beneath its surface, she's spent more than six thousand hours exploring, observing and cataloging things we never imagined existed. At 1,250 feet, she set a world record for the deepest, untethered, solo ocean dive. To most people, an accomplishment in itself. To Sylvia, it was just one more thing to do in the endless pursuit of science.




ROLEX

OYSTER PERPETUAL LADY-DATEJUST • WWW.ROLEX.COM

FOR AN OFFICIAL ROLEX JEWELER CALL 1-800-367-6539. ROLEX,  OYSTER PERPETUAL AND LADY-DATEJUST ARE TRADEMARKS.

NEW YORK



DAVID HIGGS (BOTH)

CONSERVATION

Swanning Around London

“Swan uppers” keep track of Thames swans

Centuries ago the swans that graced the Thames also graced the royal banquet table. They were the exclusive property of the British monarch, who controlled access to what was considered a luxury meat. Though swans are no longer on the palace menu, the British Queen retains ownership, along with two trade guilds, the Vintners and the Dyers, which in medieval times were allotted some of the swans—and their offspring.

To find out how many of the

thousands of swans are owned by each, and how many young swans have hatched, a census is conducted each summer along a stretch of the Thames, as it has been for more than 900 years. Now it has an added purpose: conservation.

Six teams of liveried swan uppers (so called for their cry “All up!” when a brood is sighted) conduct the count. Guild members as well as royal uppers participate. Birds are wrestled into boats (above), where they’re weighed, measured, and examined for injury. Traditionally, guild ownership was marked with nicks along the beak, but the practice was stopped in 1998; leg rings are now used.

Famously territorial, swans control their own populations. And according to David Barber (left, at right), the Queen’s official swan marker, recreational activities are the main threats these days. A 1987 ban on lead fishing weights helped increase the swan population but tangles with fishing tackle are still a danger.

—Carol Stroud



GEO NEWS

AVIATION

■ **He already made aviation history by circling the globe in a balloon without stopping.** Now pilot Steve Fossett hopes to remake aviation history. This summer, using only antique navigational instruments, he and navigator Mark Redholz will fly from Newfoundland to Ireland in a replica of a Vickers-Vimy, the biplane model that made the second transatlantic flight. John Alcock and Arthur Whitten Brown flew the original Vimy in 1919—eight years before Charles Lindbergh’s celebrated solo crossing.

HUMAN BODY

■ **Short index fingers might also mean short tempers,** a new study claims. The development of finger length in males is associated with the amount of testosterone exposure within the womb, say scientists. Men whose index fingers are shorter than their ring fingers received more of the hormone during gestation, and show a greater tendency toward physical aggression as adults. No correlation between finger length and aggression was found in women.

POLLUTION

■ **North America is exporting something Europeans don’t want: poor air quality.** A study shows that a concentration of carbon monoxide, ozone, nitrous oxide, acetone, and more can blow to Europe from the East Coast of the United States in less than one week. But European air pollution isn’t staying put. It has been found in Asia, and Asian air pollution has been detected on the West Coast of the United States.

© 2005 Microsoft Corporation. All rights reserved. Microsoft, Windows, the Windows logo, and "Your potential. Our passion." are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

Your potential. Our passion.[™]
Microsoft

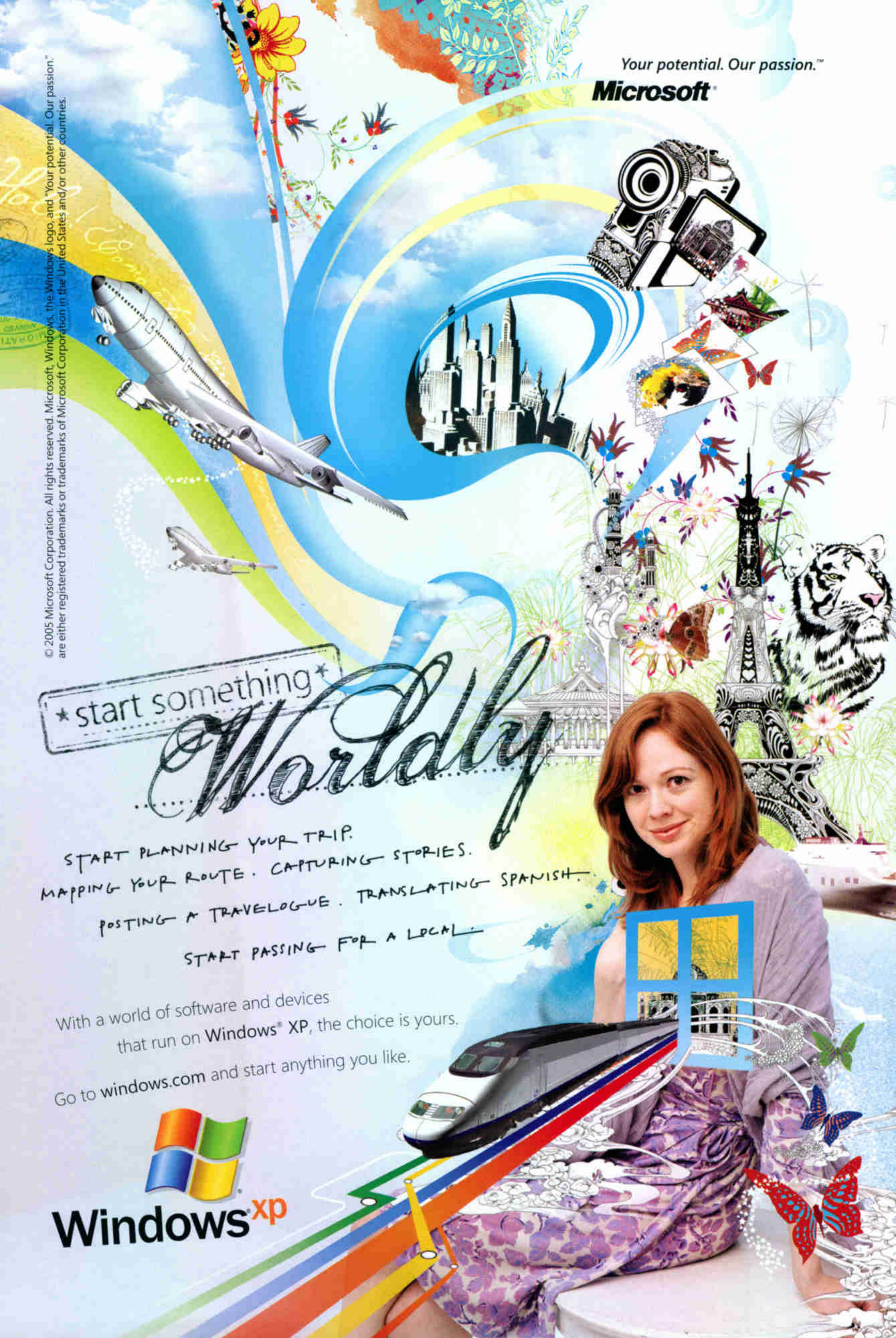
★ start something ★

Worldly

START PLANNING YOUR TRIP.
MAPPING YOUR ROUTE. CAPTURING STORIES.
POSTING A TRAVELOGUE. TRANSLATING SPANISH.
START PASSING FOR A LOCAL.

With a world of software and devices
that run on Windows[®] XP, the choice is yours.
Go to windows.com and start anything you like.


Windows^{xp}



SPACE EXPLORATION

Deep Impact

A comet's composition could reveal Earth's origins

On July 4, NASA scientists aim to punch a hole in the belly of a comet. If they're lucky, secrets of the solar system locked away for billions of years will spill out.

The unprecedented mission, named Deep Impact, is akin to a

dissection: Investigators hope that by blasting Tempel 1, an oblong comet roughly nine miles long, they'll expose its basic anatomy.

Comets are whizzing relics, mysterious amalgams of rock, ice, and dust, born with the solar system 4.5 billion years ago. They may have helped shape our cosmic neighborhood. "Many scientists think that comets brought to Earth a lot of the water and all the organics that were needed to create life," says Michael A'Hearn, the project's principal investigator.

A'Hearn explains that the size, shape, and depth of the impact crater, along with material ejected from it, will reveal the comet's structure. "Comets are key to understanding the whole planetary system," he says.

Engineers designed two vehicles for the mission, an SUV-size flyby spacecraft, equipped with

telescopes, cameras, and a spectrometer, and an 820-pound impact craft that's about the size of a washing machine. Launched in January, the flyby craft has carried the impactor to Tempel 1, 83 million miles from Earth. At about 500,000 miles from Tempel 1, it will release the impactor and retreat to record the collision. The impactor will steer itself into the comet's path, transmitting images until the comet slams into it with the force of nearly five tons of dynamite (above).

A'Hearn expects a crater about the size of a football field. What exactly Deep Impact will reveal is all part of the excitement—and anxiety—of long-distance science.

—Neil Shea

When Deep Impact reaches its target, dozens of telescopes will zoom in for the fireworks. NASA plans to post the results on the Web. Find them at nasa.gov/deepimpact.



A man in a dark suit and white shirt is balancing precariously on a staircase made of yellow envelopes. He is in a server room with rows of server racks. In the background, two security guards in black uniforms with 'SECURITY' on their backs are patrolling. The scene is lit with dramatic, low-key lighting, emphasizing the precariousness of the man's position.

Safeguard your reputation
by securing your data with
BT's networked IT services.

In the digital networked economy, it's more important than ever to keep your data secure. A breach in security can impact your day-to-day operations, affect customer confidence and harm your reputation. In fact, three out of four companies now appreciate the importance of securing critical data.* And with the rise in email and instant messaging, combined with regulatory compliance requirements about protecting and storing data, many companies are rethinking their information management policies.

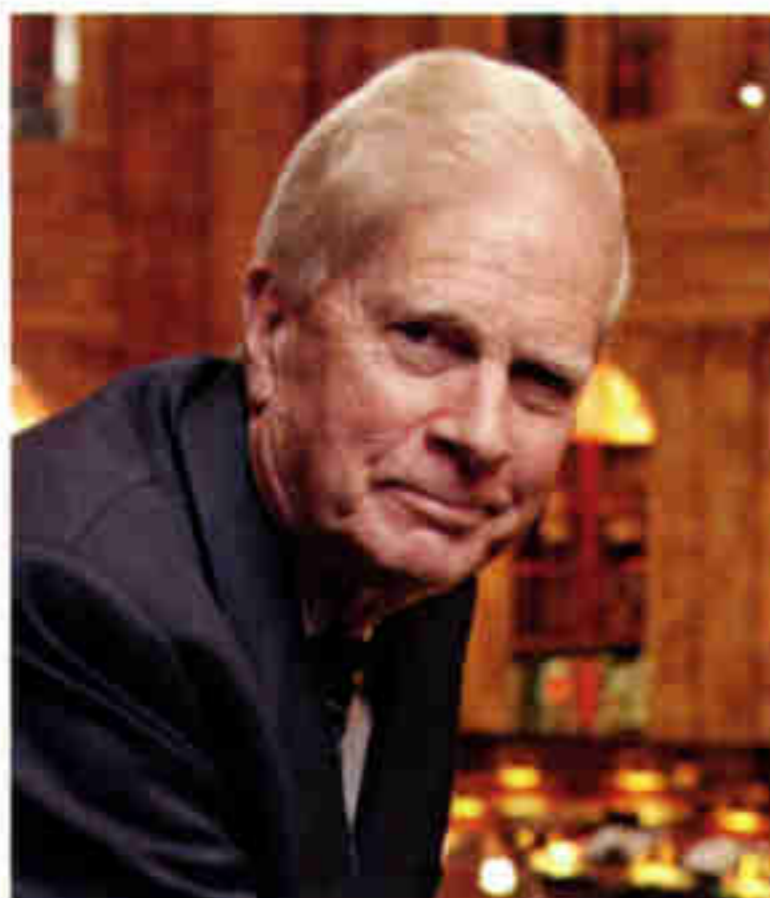
BT's networked IT services offer complete, integrated solutions to manage your applications and communications securely, ensuring information is only accessible to the right people, at the right time. That's why 60% of the largest Fortune 500 companies rely on networked IT services provided by BT.† To discover more about how BT's networked IT services can help your organization thrive, go to bt.com/networkedIT or call 1-800-331-4568.

*IDD Research, Jan 2005. †Figure based on the top 20 companies in the Fortune 500 as compiled by Fortune magazine.



More power to you

My Seven



All Booked Up

James H. Billington *Librarian of Congress, historian, reader*

Even in an age when libraries are being digitized, there will always be a place for books. As Librarian of Congress, James Billington heads one of the most impressive “book places” of all. An advocate of libraries large and small, he says, “The pursuit of truth is what keeps us from pursuing each other.” These are the libraries that have meant the most to him.

1 Nelson Billington's library My father would bring home used books from Leary's, a Philadelphia bookstore, and read every night—often aloud. He inspired my own love of reading.

2 Library of Congress Perhaps the largest and most comprehensive library in history, our collections include books, maps, music, movies, graphic arts, and more. The Library of Congress (reading room at right) symbolizes the link between knowledge and democracy.

3 Princeton University Library I was free to roam the stacks of this wonderful browsing library both as an undergraduate and later as a professor.

4 National Library of Russia, St. Petersburg All through the Soviet period libraries were great havens and great



REBECCA HALE, NGS STAFF (BOTH)

storehouses of memory at a time when public culture was tightly controlled. This collection and its curators shaped my own study of Russian history and culture.

5 Helsinki University Library This is also the National Library of Finland—the only pre-revolutionary depository of the Russian Empire that ended up in the West after 1945. It's both a beautiful and efficient place to work. I went there to study its Russian

materials; I came away with a love for Finland.

6 Vatican Library This beautiful library near the Sistine Chapel is a place for surprising discoveries. Here scholars can find gemlike collections that cover much of the opening of the modern world.

7 New York Public Library I learned about Russia from the strong collections here, but I also gained insight from the great variety of people that I

found in the library's Slavic Reading Room. We'd sit side by side, quietly working. Then we'd all break for lunch to go to the nearby Automat—and argue. But as soon as we returned and passed between the library's stone lions, all was tranquil again.

WEBSITE EXCLUSIVE

Find our Research Division's favorite resources for our stories—including books and websites—in Features at nationalgeographic.com/magazine/0507.

This Is What Happens When You Weigh Long-Lasting, Non-Drowsy Allegra 180mg Against The Alternatives.



Not one of these allergy medicines can give you long-lasting seasonal allergy relief without the risk of drowsiness.

Allegra 180 mg can.

For people 12 and over. Side effects with Allegra 180 mg are low and may include headache, cold or backache. Please see additional important information on next page.



ALLEGRA. THE RELIEF GOES ON.

ALLEGRA®**(fexofenadine hydrochloride)****Capsules and Tablets**

INDICATIONS AND USAGE Seasonal Allergic Rhinitis ALLEGRA is indicated for the relief of symptoms associated with seasonal allergic rhinitis in adults and children 6 years of age and older. Symptoms treated effectively were sneezing, rhinorrhea, itchy nose/palate/throat, itchy/watery/red eyes. **Chronic Idiopathic Urticaria** ALLEGRA is indicated for treatment of uncomplicated skin manifestations of chronic idiopathic urticaria in adults and children 6 years of age and older. It significantly reduces pruritus and the number of wheals. **CONTRAINDICATIONS** ALLEGRA is contraindicated in patients with known hypersensitivity to any of its ingredients. **PRECAUTIONS Drug Interaction with Erythromycin and Ketoconazole** Fexofenadine hydrochloride has been shown to exhibit minimal (ca. 5%) metabolism. However, co-administration of fexofenadine hydrochloride with ketoconazole and erythromycin led to increased plasma levels of fexofenadine hydrochloride. Fexofenadine hydrochloride had no effect on the pharmacokinetics of erythromycin and ketoconazole. In two separate studies, fexofenadine hydrochloride 120 mg twice daily (two times the recommended twice daily dose) was co-administered with erythromycin 500 mg every 8 hours or ketoconazole 400 mg once daily under steady state conditions to normal, healthy volunteers (n=24, each study). No differences in adverse events or QT_c interval were observed when patients were administered fexofenadine hydrochloride alone or in combination with erythromycin or ketoconazole. The findings of these studies are summarized in the following table:

Effects on steady-state fexofenadine hydrochloride pharmacokinetics after 7 days of co-administration with fexofenadine hydrochloride 120 mg every 12 hours (two times the recommended twice daily dose) in normal volunteers (n=24)

Concomitant Drug	C _{max} CS (Peak plasma concentration)	AUC _(0-12h) (Extent of systemic exposure)
Erythromycin (500 mg every 8 hrs)	+82%	+109%
Ketoconazole (400 mg once daily)	+135%	+164%

The changes in plasma levels were within the range of plasma levels achieved in adequate and well-controlled clinical trials. The mechanism of these interactions has been evaluated in *in vitro*, *in situ*, and *in vivo* animal models. These studies indicate that ketoconazole or erythromycin co-administration enhances fexofenadine gastrointestinal absorption. *In vivo* animal studies also suggest that in addition to increasing absorption, ketoconazole decreases fexofenadine hydrochloride gastrointestinal secretion, while erythromycin may also decrease biliary excretion. **Drug Interactions with Antacids** Administration of 120 mg of fexofenadine hydrochloride (2 x 60 mg capsule) within 15 minutes of an aluminum and magnesium containing antacid (Maalox®) decreased fexofenadine AUC by 41% and C_{max} by 43%. ALLEGRA should not be taken closely in time with aluminum and magnesium containing antacids. **Carcinogenesis, Mutagenesis, Impairment of Fertility** The carcinogenic potential and reproductive toxicity of fexofenadine hydrochloride were assessed using terfenadine studies with adequate fexofenadine hydrochloride exposure (based on plasma area-under-the-concentration vs. time [AUC] values). No evidence of carcinogenicity was observed in an 18-month study in mice and in a 24-month study in rats at oral doses up to 150 mg/kg of terfenadine (which led to fexofenadine exposures that were respectively approximately 3 and 5 times the exposure from the maximum recommended daily oral dose of fexofenadine hydrochloride in adults and children). In *in vitro* (Bacterial Reverse Mutation, CHO/HGPRT Forward Mutation, and Rat Lymphocyte Chromosomal Aberration assays) and *in vivo* (Mouse Bone Marrow Micronucleus assay) tests, fexofenadine hydrochloride revealed no evidence of mutagenicity. In rat fertility studies, dose-related reductions in implants and increases in postimplantation losses were observed at an oral dose of 150 mg/kg of terfenadine (which led to fexofenadine hydrochloride exposures that were approximately 3 times the exposure of the maximum recommended daily oral dose of fexofenadine hydrochloride in adults). **Pregnancy Teratogenic Effects: Category C.** There was no evidence of teratogenicity in rats or rabbits at oral doses of terfenadine up to 300 mg/kg (which led to fexofenadine exposures that were approximately 4 and 31 times, respectively, the exposure from the maximum recommended daily oral dose of fexofenadine in adults). There are no adequate and well controlled studies in pregnant women. Fexofenadine should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus. **Nonteratogenic Effects.** Dose-related decreases in pup weight gain and survival were observed in rats exposed to an oral dose of 150 mg/kg of terfenadine (approximately 3 times the maximum recommended daily oral dose of fexofenadine hydrochloride in adults based on comparison of fexofenadine hydrochloride AUCs). **Nursing Mothers** There are no adequate and well-controlled studies in women during lactation. Because many drugs are excreted in human milk, caution should be exercised when fexofenadine hydrochloride is administered to a nursing woman. **Pediatric Use** The recommended dose in patients 6 to 11 years of age is based on cross-study comparison of the pharmacokinetics of ALLEGRA in adults and pediatric patients and on the safety profile of fexofenadine hydrochloride in both adult and pediatric patients at doses equal to or higher than the recommended doses. The safety of ALLEGRA tablets at a dose of 30 mg twice daily has been demonstrated in 438 pediatric patients 6 to 11 years of age in two placebo-controlled 2-week seasonal allergic rhinitis trials. The safety of ALLEGRA for the treatment of chronic idiopathic urticaria in patients 6 to 11 years of age is based on cross-study comparison of the pharmacokinetics of ALLEGRA in adult and pediatric patients and on the safety profile of fexofenadine in both adult and pediatric patients at doses equal to or higher than the recommended dose. The effectiveness of ALLEGRA for the treatment of seasonal allergic rhinitis in patients 6 to 11 years of age was demonstrated in one trial (n=411) in which ALLEGRA tablets 30 mg twice daily significantly reduced total symptom scores compared to placebo, along with extrapolation of demonstrated efficacy in patients ages 12 years and above, and the pharmacokinetic comparisons in adults and children. The effectiveness of ALLEGRA for the treatment of chronic idiopathic urticaria in patients 6 to 11 years of age is based on an extrapolation of the demonstrated efficacy of ALLEGRA in adults with this condition and the likelihood that the disease course, pathophysiology and the drug's effect are substantially similar in children to that of adult patients. Three clinical safety studies comparing 15 mg BID (n=85) and 30 mg BID (n=330) of an experimental formulation of fexofenadine to placebo (n=430) have been conducted in pediatric patients aged 6 months to 5 years. In general, fexofenadine hydrochloride was well tolerated in these studies. No unexpected adverse events were seen given the known safety profile of fexofenadine and likely adverse reactions for this patient population. (See ADVERSE REACTIONS and CLINICAL PHARMACOLOGY.) The safety and effectiveness of fexofenadine hydrochloride in pediatric patients under 6 years of age have not been established. **Geriatric Use** Clinical studies of ALLEGRA tablets and capsules did not include sufficient numbers of subjects aged 65 years and over to determine whether this population responds differently from younger patients. Other reported clinical experience has not identified differences in responses between the geriatric and younger patients. This drug is known to be substantially excreted by the kidney, and the risk of toxic reactions to this drug may be greater in patients with impaired renal function. Because elderly patients are more likely to have decreased renal function, care should be taken in dose selection, and may be useful to monitor renal function. (See CLINICAL PHARMACOLOGY.) **ADVERSE REACTIONS Seasonal Allergic Rhinitis Adults.** In placebo-controlled seasonal allergic rhinitis clinical trials in patients 12 years of age and older, which included 2461 patients receiving fexofenadine hydrochloride capsules at doses of 20 mg to 240 mg twice daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. All adverse events that were reported by greater than 1% of patients who received the recommended daily dose of fexofenadine hydrochloride (60 mg capsules twice daily), and that were more common with fexofenadine hydrochloride than placebo, are listed in Table 1. In a placebo-controlled clinical study in the United States, which included 570 patients aged 12 years and older receiving fexofenadine hydrochloride tablets at doses of 120 or 180 mg once daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. Table 1 also lists adverse experiences that were reported by greater than 2% of patients treated with fexofenadine hydrochloride tablets at doses of 180 mg once daily and that were more common with fexofenadine hydrochloride than placebo. The incidence of adverse events, including drowsiness, was not dose-related and was similar across subgroups defined by age, gender, and race.

Table 1
Adverse experiences in patients ages 12 years and older reported in placebo-controlled seasonal allergic rhinitis clinical trials in the United States

Adverse experience	Twice daily dosing with fexofenadine capsules at rates of greater than 1%	
	Fexofenadine 60 mg Twice Daily (n=679)	Placebo Twice Daily (n=671)
Viral Infection (cold, flu)	2.5%	1.5%
Nausea	1.6%	1.5%
Dysmenorrhea	1.5%	0.3%
Drowsiness	1.3%	0.9%
Dyspepsia	1.3%	0.6%
Fatigue	1.3%	0.9%

Once daily dosing with fexofenadine hydrochloride tablets at rates of greater than 2%

Adverse experience	Fexofenadine 180 mg once daily (n=283)	Placebo (n=293)
Headache	10.6%	7.5%
Upper Respiratory Tract Infection	3.2%	3.1%
Back Pain	2.8%	1.4%

The frequency and magnitude of laboratory abnormalities were similar in fexofenadine hydrochloride and placebo-treated patients. **Pediatric.** Table 2 lists adverse experiences in patients aged 6 to 11 years of age which were reported by greater than 2% of patients treated with fexofenadine hydrochloride tablets at a dose of 30 mg twice daily in placebo-controlled seasonal allergic rhinitis studies in the United States and Canada that were more common with fexofenadine hydrochloride than placebo.

Table 2
Adverse experiences reported in placebo-controlled seasonal allergic rhinitis studies in pediatric patients ages 6 to 11 in the United States and Canada at rates of greater than 2%

Adverse experience	Fexofenadine 30 mg twice daily (n=209)	Placebo (n=229)
Headache	7.2%	6.6%
Accidental Injury	2.9%	1.3%
Coughing	3.8%	1.3%
Fever	2.4%	0.9%
Pain	2.4%	0.4%
Otitis Media	2.4%	0.0%
Upper Respiratory Tract Infection	4.3%	1.7%

Three clinical safety studies in 845 children aged 6 months to 5 years comparing 15 mg BID (n=85) and 30 mg BID (n=330) of an experimental formulation of fexofenadine to placebo (n=430) have been conducted. In general, fexofenadine hydrochloride was well tolerated in these studies. No unexpected adverse events were seen given the known safety profile of fexofenadine and likely adverse reactions for this patient population. (See PRECAUTIONS Pediatric Use.) **Chronic Idiopathic Urticaria** Adverse events reported by patients 12 years of age and older in placebo-controlled chronic idiopathic urticaria studies were similar to those reported in placebo-controlled seasonal allergic rhinitis studies. In placebo-controlled chronic idiopathic urticaria clinical trials, which included 726 patients 12 years of age and older receiving fexofenadine hydrochloride tablets at doses of 20 to 240 mg twice daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. Table 3 lists adverse experiences in patients aged 12 years and older which were reported by greater than 2% of patients treated with fexofenadine hydrochloride 60 mg tablets twice daily in controlled clinical studies in the United States and Canada and that were more common with fexofenadine hydrochloride than placebo. The safety of fexofenadine hydrochloride in the treatment of chronic idiopathic urticaria in pediatric patients 6 to 11 years of age is based on the safety profile of fexofenadine hydrochloride in adults and adolescent patients at doses equal to or higher than the recommended dose (see Pediatric Use).

Table 3
Adverse experiences reported in patients 12 years and older in placebo-controlled chronic idiopathic urticaria studies in the United States and Canada at rates of greater than 2%

Adverse experience	Fexofenadine 60 mg twice daily (n=186)	Placebo (n=178)
Back Pain	2.2%	1.1%
Sinusitis	2.2%	1.1%
Dizziness	2.2%	0.6%
Drowsiness	2.2%	0.0%

Events that have been reported during controlled clinical trials involving seasonal allergic rhinitis and chronic idiopathic urticaria patients with incidences less than 1% and similar to placebo and have been rarely reported during postmarketing surveillance include: insomnia, nervousness, and sleep disorders or paroniria. In rare cases, rash, urticaria, pruritus and hypersensitivity reactions with manifestations such as angioedema, chest tightness, dyspnea, flushing and systemic anaphylaxis have been reported. **OVERDOSAGE** Reports of fexofenadine hydrochloride overdose have been infrequent and contain limited information. However, dizziness, drowsiness, and dry mouth have been reported. Single doses of fexofenadine hydrochloride up to 800 mg (six normal volunteers at this dose level), and doses up to 690 mg twice daily for 1 month (three normal volunteers at this dose level) or 240 mg once daily for 1 year (234 normal volunteers at this dose level) were administered without the development of clinically significant adverse events as compared to placebo. In the event of overdose, consider standard measures to remove any unabsorbed drug. Symptomatic and supportive treatment is recommended. Hemodialysis did not effectively remove fexofenadine hydrochloride from blood (1.7% removed) following terfenadine administration. No deaths occurred at oral doses of fexofenadine hydrochloride up to 5000 mg/kg in mice (110 times the maximum recommended daily oral dose in adults and 200 times the maximum recommended daily oral dose in children based on mg/m²) and up to 5000 mg/kg in rats (230 times the maximum recommended daily oral dose in adults and 400 times the maximum recommended daily oral dose in children based on mg/m²). Additionally, no clinical signs of toxicity or gross pathological findings were observed. In dogs, no evidence of toxicity was observed at oral doses up to 2000 mg/kg (300 times the maximum recommended daily oral dose in adults and 530 times the maximum recommended daily oral dose in children based on mg/m²). **DOSAGE AND ADMINISTRATION Seasonal Allergic Rhinitis Adults and Children 12 Years and Older.** The recommended dose of ALLEGRA is 60 mg twice daily, or 180 mg once daily. A dose of 60 mg once daily is recommended as the starting dose in patients with decreased renal function (see CLINICAL PHARMACOLOGY). **Children 6 to 11 Years.** The recommended dose of ALLEGRA is 30 mg twice daily. A dose of 30 mg once daily is recommended as the starting dose in pediatric patients with decreased renal function (see CLINICAL PHARMACOLOGY). **Chronic Idiopathic Urticaria Adults and Children 12 Years and Older.** The recommended dose of ALLEGRA is 60 mg twice daily. A dose of 60 mg once daily is recommended as the starting dose in patients with decreased renal function (see CLINICAL PHARMACOLOGY). **Children 6 to 11 Years.** The recommended dose of ALLEGRA is 30 mg twice daily. A dose of 30 mg once daily is recommended as the starting dose in pediatric patients with decreased renal function (see CLINICAL PHARMACOLOGY). Please see product circular for full prescribing information.

Rx only

Rev. May 2003a

Brief Summary

Aventis Pharmaceuticals Inc.

Kansas City, MO 64137 USA

US Patents 4,254,129; 5,375,693; 5,578,610

©2003 Aventis Pharmaceuticals Inc.

www.allegra.com

all-may03a-B-AJ

The fastest way to learn a language. Guaranteed.™

Finally, a different approach that has millions of people talking. Using the award-winning Dynamic Immersion™ method, our interactive software teaches without translation, memorization or grammar drills. Combining thousands of real-life images and the voices of native speakers in a step-by-step immersion process, our programs successfully replicate the experience of learning your first language. Guaranteed to teach faster and easier than any other language product or your money back. No questions asked.



Spanish (Latin America or Spain) **French** **German** **Japanese** **Thai** **Arabic** **Turkish** **Polish** **Swedish**
English (US or UK) **Italian** **Russian** **Indonesian** **Korean** **Hebrew** **Danish** **Welsh** **Pashto**
Portuguese **Chinese** **Vietnamese** **Hindi** **Greek** **Swahili** **Dutch** **Latin**

Award-winning software successfully used by U.S. State Department diplomats, Fortune 500® executives and millions of people worldwide.

Step-by-step immersion instruction in all key language skills:



Listening - Rosetta Stone uses native speakers and everyday language to develop your understanding of the spoken language naturally and easily.



Reading - Text exercises develop your reading skills by linking written language to real-life objects, actions and ideas.



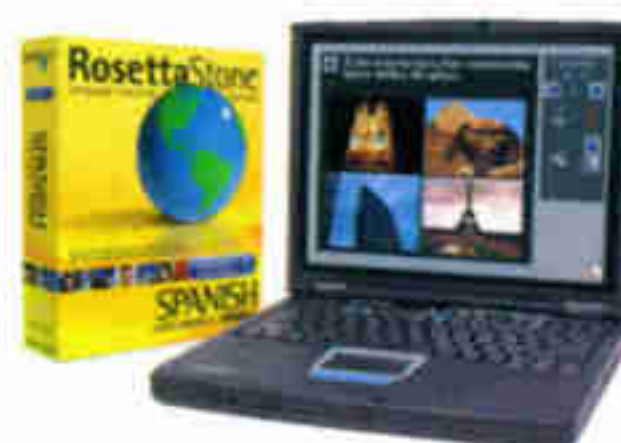
Speaking - Speech-recognition feature records, diagrams and compares your voice to the native speaker's, grading your pronunciation.



Writing - Dictation exercises evaluate your spelling, syntax and punctuation.

Each fully interactive course includes:

- CD-ROM curriculum with 20 activities in each of 92 lessons
- Previews, comprehensive exercises and testing for each lesson
- Automated tutorials that "learn" where you need extra help
- Curriculum Text and 45-page User's Guide



Save 10%

Level 1 Program
Regularly ~~\$195.00~~



Your Price
\$175.50

Level 2 Program
Regularly ~~\$225.00~~



Your Price
\$202.50

Level 1 & 2
Regularly ~~\$329.00~~



BEST VALUE!

Your Price
\$296.10

Personal Edition. Solutions for organizations also available.

Call today or buy online
for a 10% discount.

RosettaStone.com/ngs075

1-877-718-7097

Use promotional code ngs075 when ordering.

RosettaStone®
Language Learning Success



"...your program is the absolute best, bar none. I am shocked at how quickly I learn."

- Michael Murphy
Texas, USA

"Stupendous...the juxtaposition of text, sound and picture was masterful. The quality of both sound and graphics was first rate."

- The Boston Globe

ON ASSI

ON THE ROAD, IN THE FIELD,



GOVERNMENT

C O V E R I N G T H E

W O R L D

THE STEM CELL DIVIDE

Double Duty

M.D. calls the shots for stem cell story

It was the drama of photographing a spinal cord operation that moved photojournalist **Max Aguilera-Hellweg** (left) to change careers. “The patient hung vertically so his vertebrae stretched out,” he recalls. “When I saw the spinal cord exposed, it was like going to the moon. It was so pure. I knew I wanted to feel that awe over and over again.”

So at age 39, Max turned back to basics—with a course in pre-algebra. By 44 he was in medical school. And then, in the first year of his residency, NATIONAL GEOGRAPHIC called with the stem cell assignment.

“Here I was fresh out of med school, and I was clueless about stem cells. To be honest, I think most doctors are,” he says. So with the OK from his boss at the University of Massachusetts Medical Center, he packed up 11 trunks of camera gear and set out for a whirlwind education in stem cell science.

“I met the researchers and recovering patients, and I witnessed one incredible study after another,” he says. The work using the mouse at left “showed that human brain stem cells injected into a mouse will function properly—that they’ll even find and repair damage. It’s hard to come to terms with how powerful these things are.”

ROBERT HOLMGREN



WORLDWIDE



NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN

GLEN ECHO, MARYLAND

How do you capture the spirit of a town like Glen Echo? "I knew we couldn't do it in four photographs," says illustrations editor **Susan Welchman**. She turned instead to artist **Carol Barton** (above). Carol has been creating pop-up books for more than 20 years and has a gift for creating three-dimensional collages that convey much more than the sum of their parts. They're expansive, enticing, alternate realities. "In her art the rules of perspective are thrown out, and the size and placement of buildings and people become part of a new reality—Carol's," says **Chris Sloan**, senior editor for art. "The result is real and funky—like Glen Echo."

Carol chose a medium that was new to her for the project: She used photos instead of artwork as her raw materials. To craft a pop-up of a large structure using photography, says Carol, you have to shoot the building in sections to prevent distortion and then digitally merge them into a single image. To get that perfect,

merged result, she worked closely with photographer **Michael Brown**, who took thousands of photos for the pop-ups.

Compiling her subject list was easier. Having lived in Glen Echo for 20 years, Carol knows just about everyone in the arts-friendly hamlet. Her depiction includes icons like the 1933 ballroom where dancers still swing, the carousel, and the yurts used as art studios. She also managed to work in a few personal details: That's her partner, Henry Barrow, riding his bike across page 116. And on the article's last page, that's Michael taking a picture from his perch on the roof of the popcorn stand.

CHINA'S GREAT ARMADA

"This particular story was a dream assignment for me," says writer and historian **Frank Viviano**. On the road for four months, he and photographer **Mike Yamashita** traced the voyages of Zheng He, a 15th-century Chinese admiral, from southeastern China to the coast of Africa. "I made most of the trip in airplanes, and it still left me exhausted," says Frank. "It gave me a real respect for

the seamen who completed this enormous journey not just once, but seven times. And they did it in junks."

Many people they met on Zheng He's trail had never heard of him, but reminders of his journey were everywhere. "You can still see things that Zheng He would have seen," Mike says. In Yemen, for example, women still wear veils described in the Chinese armada's records. And on Java, Indonesia, some men still carry huge knives in their belts.

TAPPING THE ROCKIES

As photographer **Joel Sartore** drove through the Rocky Mountains, classic cowboy panoramas sliding by his window, he puzzled over a way to shoot a landscape that was transforming before his eyes. Then he hit upon the idea for the photograph on page 95. An avid aquarium keeper since childhood, Joel put a few minnows from Wyoming's Powder River in a homemade tank and shot them circling above their river. "The aquarium image is emblematic of the story and the area's changing face," he says.

"The Powder is one of the last undammed prairie rivers in the U.S. that still has its original complement of fish, and it's going to be hammered by drilling," says Joel. In the next six years 35,000 new methane wells are planned for the river basin. "I want to make sure people know what's going on out there," he says. "If we plunder this area for cheap energy, then we get the landscape we deserve."

TALES FROM THE FIELD Find more stories from our contributors, including their best, worst, and quirkiest experiences, in Features at nationalgeographic.com/magazine/0507.

Toyota's South Campus complex in Torrance, California received Gold Level Certification for Leadership in Energy and Environmental Design (LEED®) from the U.S. Green Building Council.



A business environment where the emphasis is on “environment.”

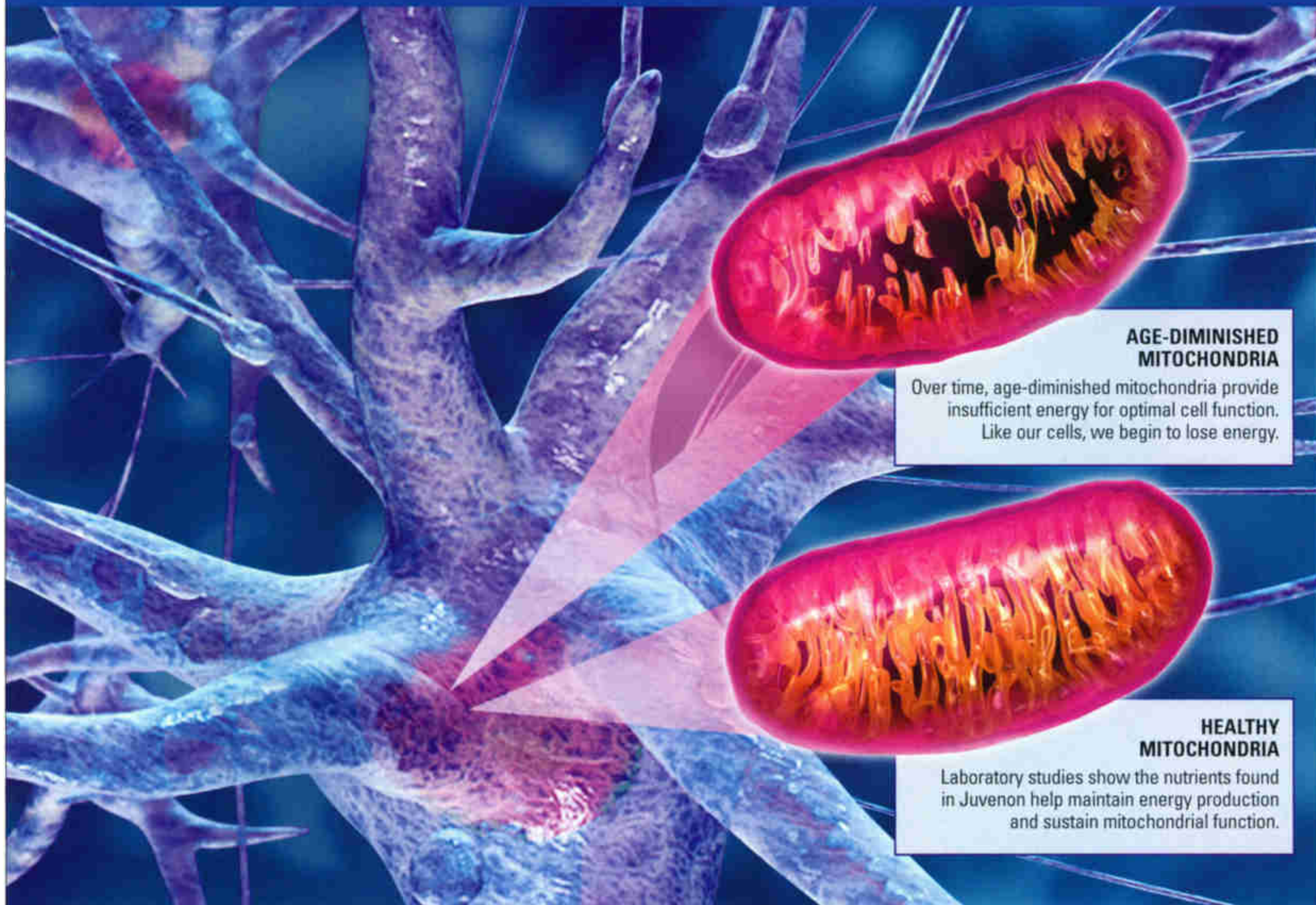
This striking new building, part of Toyota's U.S. sales and financial headquarters in Southern California, was built using materials from scrapped cars. It contains over 90% recycled content and is powered by one of the largest privately owned solar arrays in America. Toyota is a global leader in environmental innovations like hybrid technology, and as we continue to grow in the U.S., we'll keep searching for new ways to ensure that all of our operations are as environmentally responsible as possible. Caring for the Earth: we think it's good business.

©2005

toyota.com/environment

TOYOTA

ENLARGEMENT OF MITOCHONDRIA FOUND INSIDE A HUMAN BRAIN CELL



**AGE-DIMINISHED
MITOCHONDRIA**

Over time, age-diminished mitochondria provide insufficient energy for optimal cell function. Like our cells, we begin to lose energy.

**HEALTHY
MITOCHONDRIA**

Laboratory studies show the nutrients found in Juvenon help maintain energy production and sustain mitochondrial function.

Slow Down The Clock On Your Aging Cells.

AT THE UNIVERSITY OF CALIFORNIA, BERKELEY, AN AWARD-WINNING TEAM OF SCIENTISTS has been conducting pre-clinical studies on aging. They discovered that by using the right combination of a natural, energy-boosting component with a powerful anti-oxidant they could slow the cell aging process. The result is Juvenon™, a patented cellular health supplement.

Research found that a central factor in aging is the decay of the mitochondria in cells. These are the biological engines that convert carbohydrates, fats and proteins into energy. Aging mitochondria are less efficient at converting fuel to energy, and they produce more toxic oxidants. Taking Juvenon™ every day helps maintain the percentage of healthy mitochondria in cells and slows down the cellular aging process.



**Sustains Energy
Level**



**Promotes Brain
Cell Function**



**Supports Metabolic
Efficiency**

Order Today and Save \$5

Promotional Code: NG506

www.juvenon.com

**1-800-JUVENON
(1-800-588-3666)**

100% Satisfaction Guarantee!
Not available in stores.



Who Knew?

PALEONTOLOGY

Dino-size

Why were dinosaurs so humongous?

One of the most cherished features of dinosaurs—their gigantism—is also one of the most mysterious. Why in the world were these animals so huge?

Any explanation has to start with the arms-race theory: Some species of dinosaurs may have evolved to a larger stature as a way of escaping predators or gaining a competitive advantage. When you're a predator, you usually don't like to mess with a creature that can stomp you like a bug. Studies of growth rings in dinosaur bones by Greg Erickson of Florida State University and others show that baby dinosaurs grew to maturity at dazzling speed. They practically exploded from their eggs. A bouncy little apatosaur could become a 30-ton beast in just 20 years.

Tyrannosaurs, the dominant meat-eaters of the late Cretaceous, grew steadily until they were teenagers and then went through a growth spurt, becoming five times larger in just seven years. That meant that one species came in two lethal sizes—medium and large—and could effectively dominate two

ecological niches. The juvenile *T. rex* devoured the little animal nuggets and Big Daddy *T. rex* handled the supersize meals.

But there's a problem with the simple bigger-is-better explanation: Most dinosaurs weren't giants. Small bones don't preserve as well, so the fossils (and museum displays) tend to overrepresent the behemoths. There were plenty of dog-size and even chicken-size dinosaurs, and one, known as *Microraptor*, no bigger than a pigeon. That guy was a real terror.

Gigantism doesn't go on forever: Many of the biggest dinosaurs found their numbers thinning at some point, their niches largely replaced by creatures only half their size. It's as though evolving toward larger size is rewarding for a while—and then the bill comes due.

Sara Decherd, a doctoral candidate at North Carolina State, has studied the plants available during the age of dinosaurs and suggests that the rise of flowers may be connected to a decline of the largest dinosaurs. You'd think that nutritious plants would lead to bigger dinosaurs, but it's the other way around. During the Jurassic, vegetation tended to consist of fibrous, low-nutrient plants such as gymnosperms.

Decherd says that gigantism may have arisen in part to give dinosaurs big stomachs that could act like fermenting vats.

With the dramatic arrival of high-nutrient angiosperms, or flowering plants, the largest dinosaurs began to vanish.

Matt Carrano, dinosaur curator at the Smithsonian's National Museum of Natural History, says that many lines of dinosaurs may have evolved toward gigantism simply because they could. "Given enough time," says Carrano, "you'll explore all the different sizes you can potentially be."

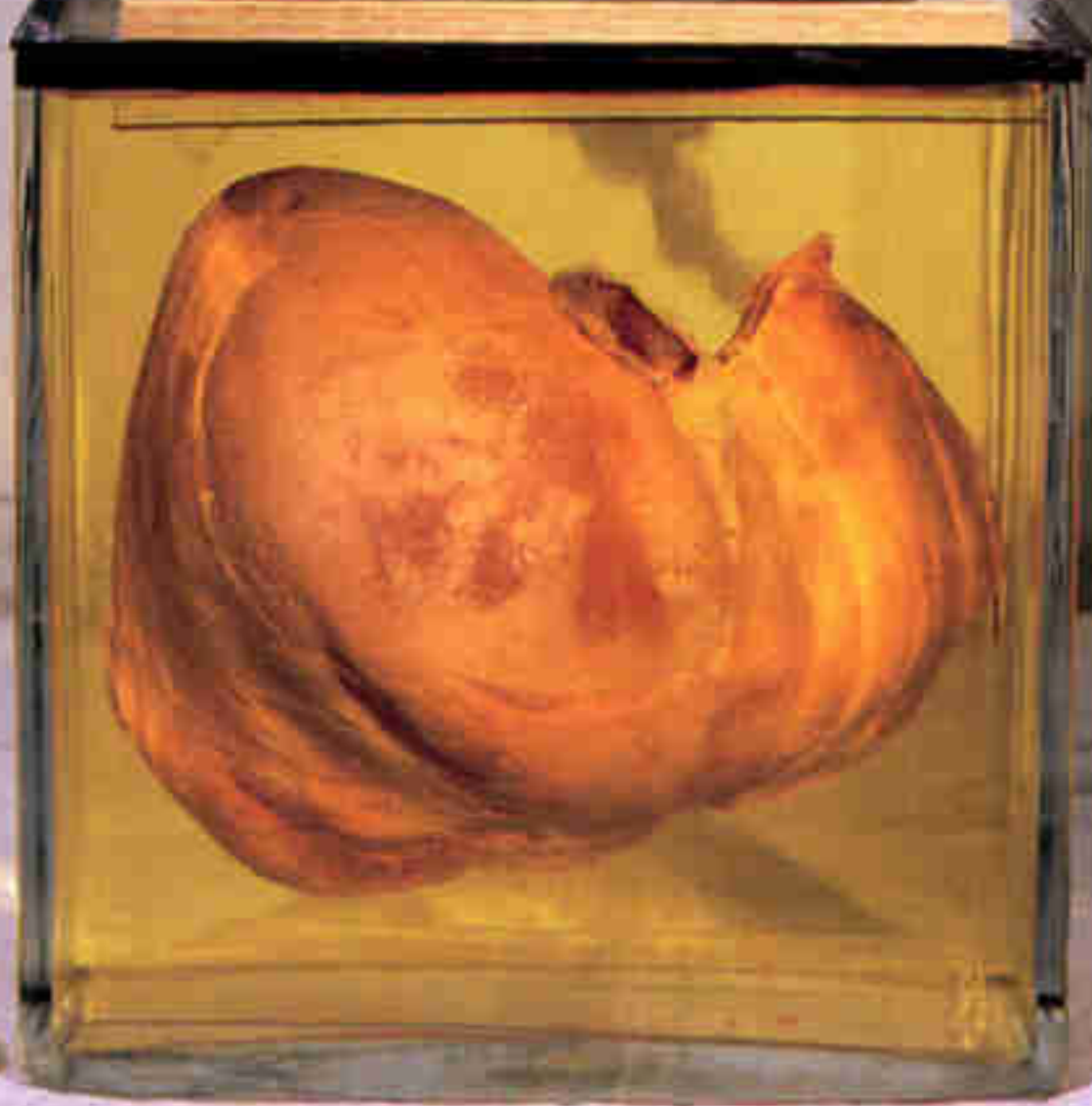
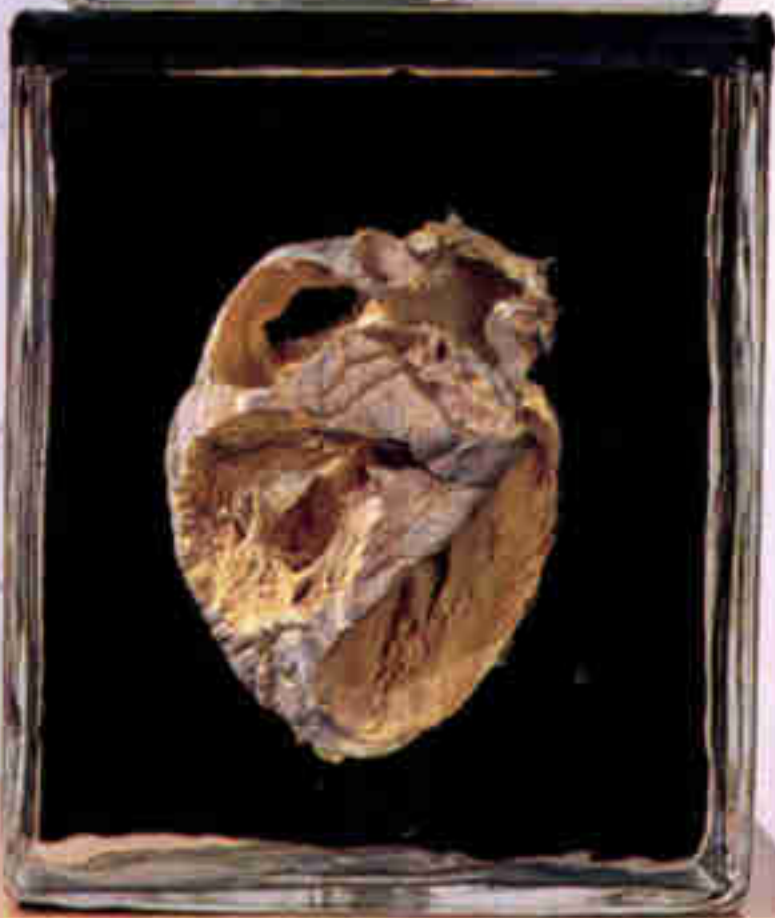
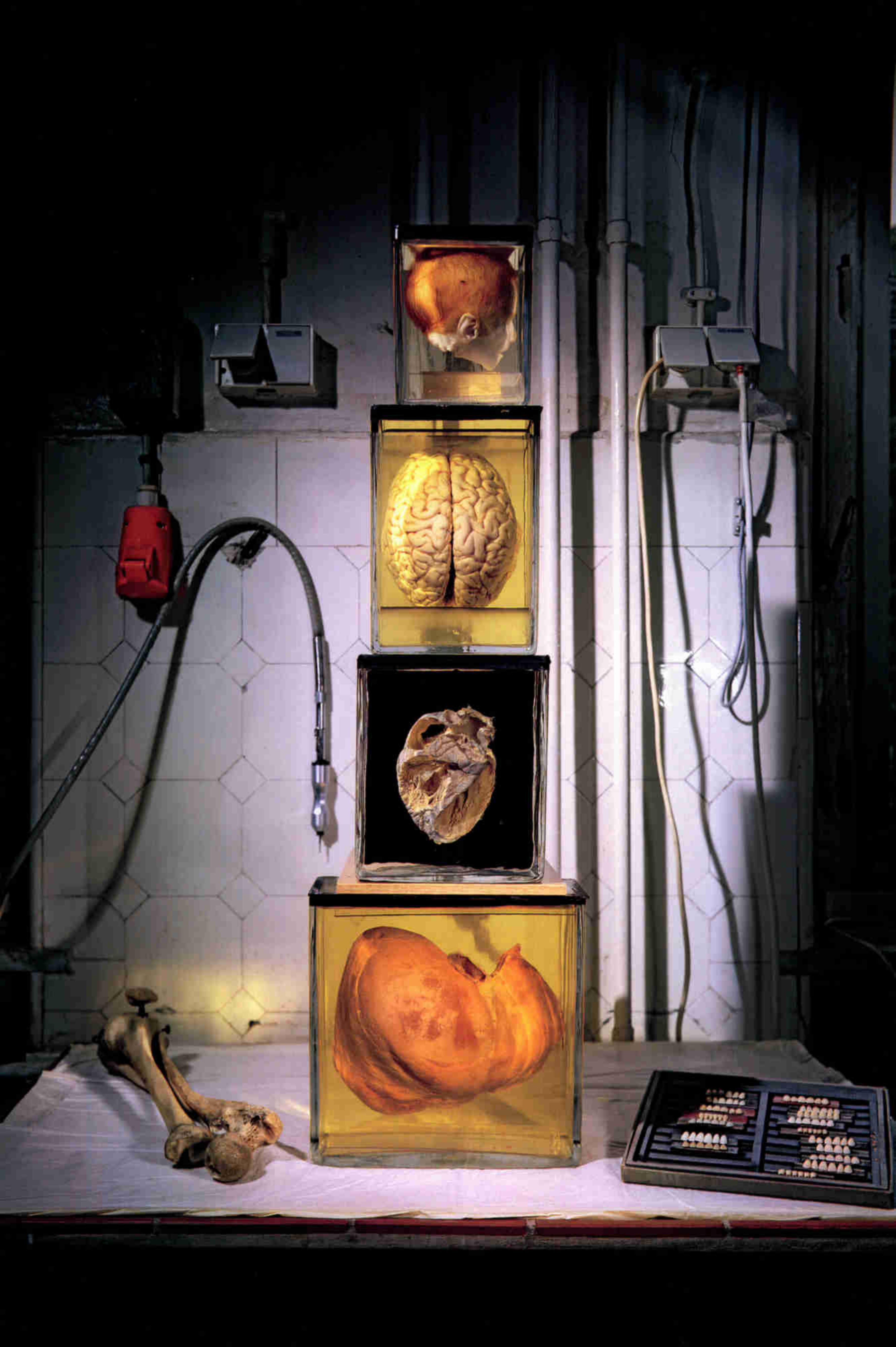
Perhaps the real question should be, Why aren't mammals bigger? Reproductive strategies surely hold the answer. Mammals gestate their young, and the biggest mammals have the longest gestation periods. This is a slow process that results in relatively few offspring, and the big mammals can't easily adapt to an environmental crisis. Carrano says, "There are benefits to being big, but at some point the benefits are outweighed by the risks."

In concluding that bigger may not be better after all, keep in mind that only one line of rather small dinosaurs survived the end-of-Cretaceous mass extinction. They're called birds.

—Joel Achenbach

WASHINGTON POST STAFF WRITER

WEBSITE EXCLUSIVE For more about dinosaurs, and for links to Joel Achenbach's work, go to Departments at nationalgeographic.com/magazine/0507.

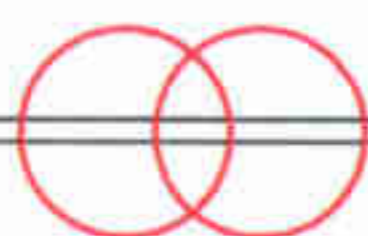


Immature and full of potential, stem cells haven't yet differentiated into the specialized cells that form body parts, like the museum specimens (left) stacked in the Berlin lab of pathologist Rudolf Virchow. He pioneered the idea, in the 1800s, that disease begins at the cellular level.

The Power to Divide

stem cells could launch a new era of medicine, curing deadly diseases with custom-made tissues and organs. But science may take a backseat to politics in deciding if—and where—that hope will be realized.

By Rick Weiss | Photographs by Max Aguilera-Hellweg, M.D.







hoping for a cure

Eleven-year-old David Dalmat waits in a Paris hospital for a bone marrow transplant to treat his sickle-cell anemia. In use for decades, such transplants are an example of an “adult” stem cell therapy in which stem cells in donated bone marrow regenerate a patient’s blood and immune system. To thwart his disease—and fend off the risk of rejection—David’s own bone marrow has been wiped out by radiation and chemotherapy. Until it’s regrown, he’s a “boy in a bubble,” isolated from a microbe-infested world.



cell roundup

To see if a biopsy from an eye contains stem cells useful for corneal repair, scientists stain the sample to gauge cell growth. Large, well-rounded colonies result from heavy proliferation, suggesting that stem cells may be present.

IN THE BEGINNING, one cell becomes two, and two become four. Being fruitful, they multiply into a ball of many cells, a shimmering sphere of human potential. Scientists have long dreamed of plucking those naive cells from a young human embryo and coaxing them to perform, in sterile isolation, the everyday miracle they perform in wombs: transforming into all the 200 or so kinds of cells that constitute a human body. Liver cells. Brain cells. Skin, bone, and nerve.

The dream is to launch a medical revolution in which ailing organs and tissues might be repaired—not with crude mechanical devices like insulin pumps and titanium joints but with living, homegrown replacements. It would be the dawn of a new era of regenerative medicine, one of the holy grails of modern biology.

Revolutions, alas, are almost always messy. So when James Thomson, a soft-spoken scientist at the University of Wisconsin in Madison, reported in November 1998 that he had succeeded in removing cells from spare embryos at fertility clinics and establishing the world's first human embryonic stem cell line, he and other scientists got a lot more than they bargained for. It was the kind of discovery that under most circumstances would have blossomed into a major federal research enterprise. Instead the discovery was quickly engulfed in the turbulent waters of religion and politics. In church pews, congressional hearing rooms, and finally the Oval Office, people wanted to know: Where were

the needed embryos going to come from, and how many would have to be destroyed to treat the millions of patients who might be helped? Before long, countries around the world were embroiled in the debate.

Most alarmed have been people who see embryos as fully vested, vulnerable members of society, and who decry the harvesting of cells from embryos as akin to cannibalism. They warn of a brave new world of “embryo farms” and “cloning mills” for the cultivation of human spare parts. And they argue that scientists can achieve the same results using adult stem cells—immature cells found in bone marrow and other organs in adult human beings, as well as in umbilical cords normally discarded at birth.

Advocates counter that adult stem cells, useful as they may be for some diseases, have thus far proved incapable of producing the full range of cell types that embryonic stem cells can. They point out that fertility clinic freezers worldwide are bulging with thousands of unwanted embryos slated for disposal. Those embryos are each smaller than the period at the end of this sentence. They have no identifying features or hints of a nervous system. If parents agree to donate them, supporters say, it would be unethical *not* to do so in the quest to cure people of disease.

Few question the medical promise of embryonic stem cells. Consider the biggest United States killer of all: heart disease. Embryonic stem cells can be trained to grow into heart muscle cells that, even in a laboratory dish, clump together and pulse in spooky unison. And when those heart cells have been injected into mice and pigs with heart disease, they’ve filled in for injured or dead cells and sped recovery. Similar studies have suggested stem cells’ potential for conditions such as diabetes and spinal cord injury.

Critics point to worrisome animal research showing that embryonic stem cells sometimes grow into tumors or morph into unwanted kinds of tissues—possibly forming, for example, dangerous bits of bone in those hearts they are supposedly repairing. But supporters respond that such problems are rare and a lot has recently been learned about how to prevent them.

The arguments go back and forth, but policymakers and governments aren’t waiting for answers. Some countries, such as Germany, worried about a slippery slope toward unethical human experimentation, have already prohibited

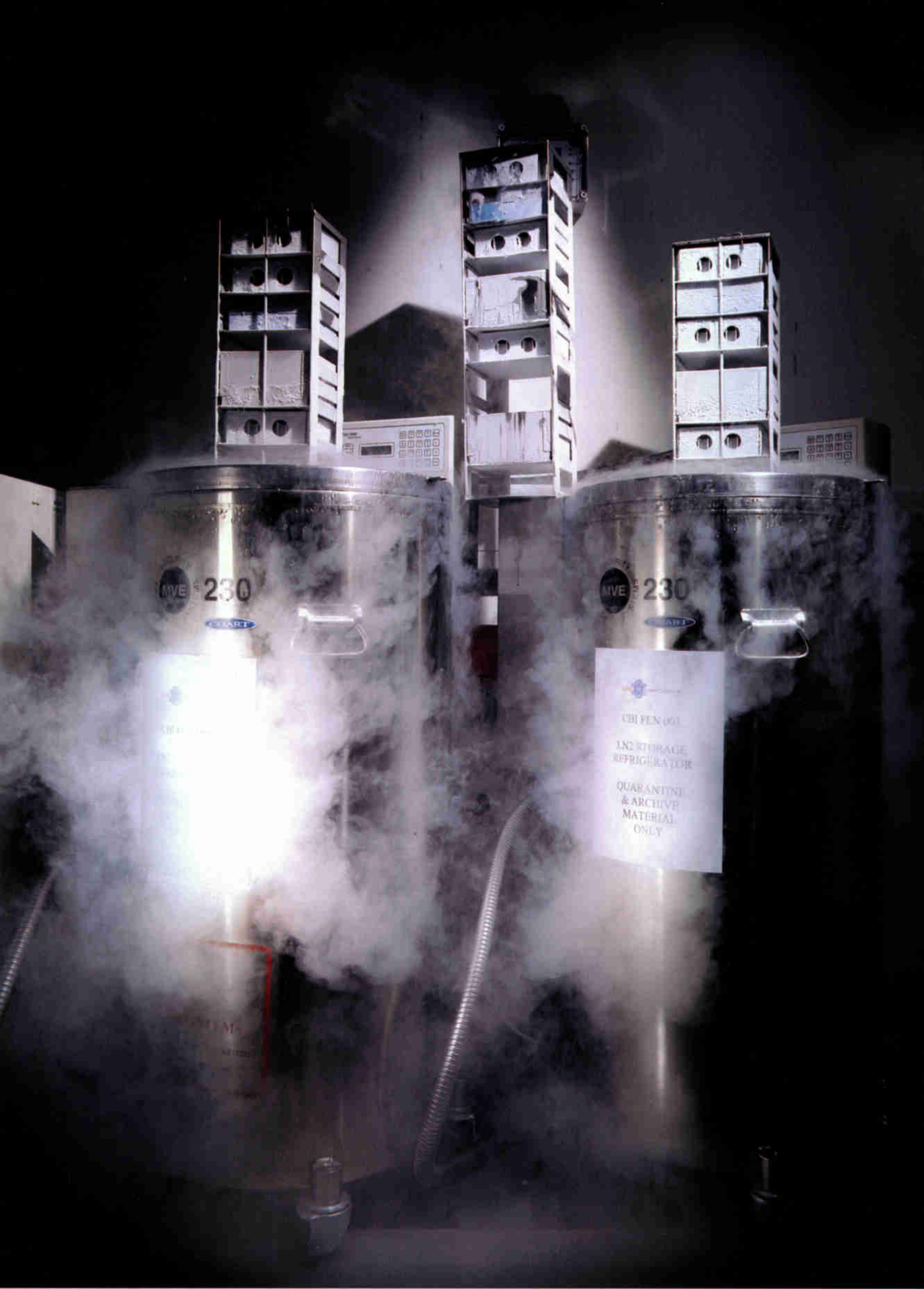
some types of stem cell research. Others, like the U.S., have imposed severe limits on government funding but have left the private sector to do what it wants. Still others, such as the U.K., China, Korea, and Singapore, have set out to become the epicenters of stem cell research, providing money as well as ethical oversight to encourage the field within carefully drawn bounds.

In such varied political climates, scientists around the globe are racing to see which techniques will produce treatments soonest. Their approaches vary, but on one point, all seem to agree: How humanity handles its control over the mysteries of embryo development will say a lot about who we are and what we’re becoming.

FOR MORE THAN HALF of his seven years, Cedric Seldon has been fighting leukemia. Now having run out of options, he is about to become a biomedical pioneer—one of about 600 Americans last year to be treated with an umbilical cord blood transplant.

Cord blood transplants—considered an adult stem cell therapy because the cells come from infants, not embryos—have been performed since 1988. Like bone marrow, which doctors have been transplanting since 1968, cord blood is richly endowed with a kind of stem cell that gives rise to oxygen-carrying red blood cells, disease-fighting white blood cells, and other parts of the blood and immune systems. Unlike a simple blood transfusion, which provides a batch of cells destined to die in a few months, the stem cells found in bone marrow and cord blood can—if all goes well—burrow into a person’s bones, settle there for good, and generate fresh blood and immune cells for a lifetime.

Propped on a hospital bed at Duke University Medical Center, Cedric works his thumbs furiously against a pair of joysticks that control a careening vehicle in a Starsky and Hutch video game. “Hang on, Hutch!” older brother Daniel shouts from the bedside, as a nurse, ignoring the screeching tires and gunshots, sorts through a jumble of tubes and hangs a bag of cord blood cells from a chrome pole. Just an hour ago I watched those cells being thawed and spun in a centrifuge—awakening them for the first time since 2001, when they were extracted from the umbilical cord of a newborn and donated by her parents to a cell bank at Duke. The time has come for those cells to prove *(Continued on page 15)*



With more and more countries aggressively developing stem cell therapies, the United States is in real danger of being left behind.

the stem cell race

Although embryonic stem cell science got its start in the U.S., the rest of the world is fighting to take the lead. With one of the most research-friendly climates in Europe, the United Kingdom allows scientists to extract stem cells from embryos left over from in vitro fertilization as well as to clone embryos specifically for study. At the U.K. Stem Cell Bank—the first of its type in the world—vessels (left) for cold-stored cell lines are a repository for the future, says the bank's director Glyn Stacey. Researchers can deposit and withdraw both adult and embryonic stem cells. "The idea is to apply the same rigorous standards to all cells," Stacey says. Scientists hope to create batches of stem cells as uniform as the drugs produced by pharmaceutical companies.

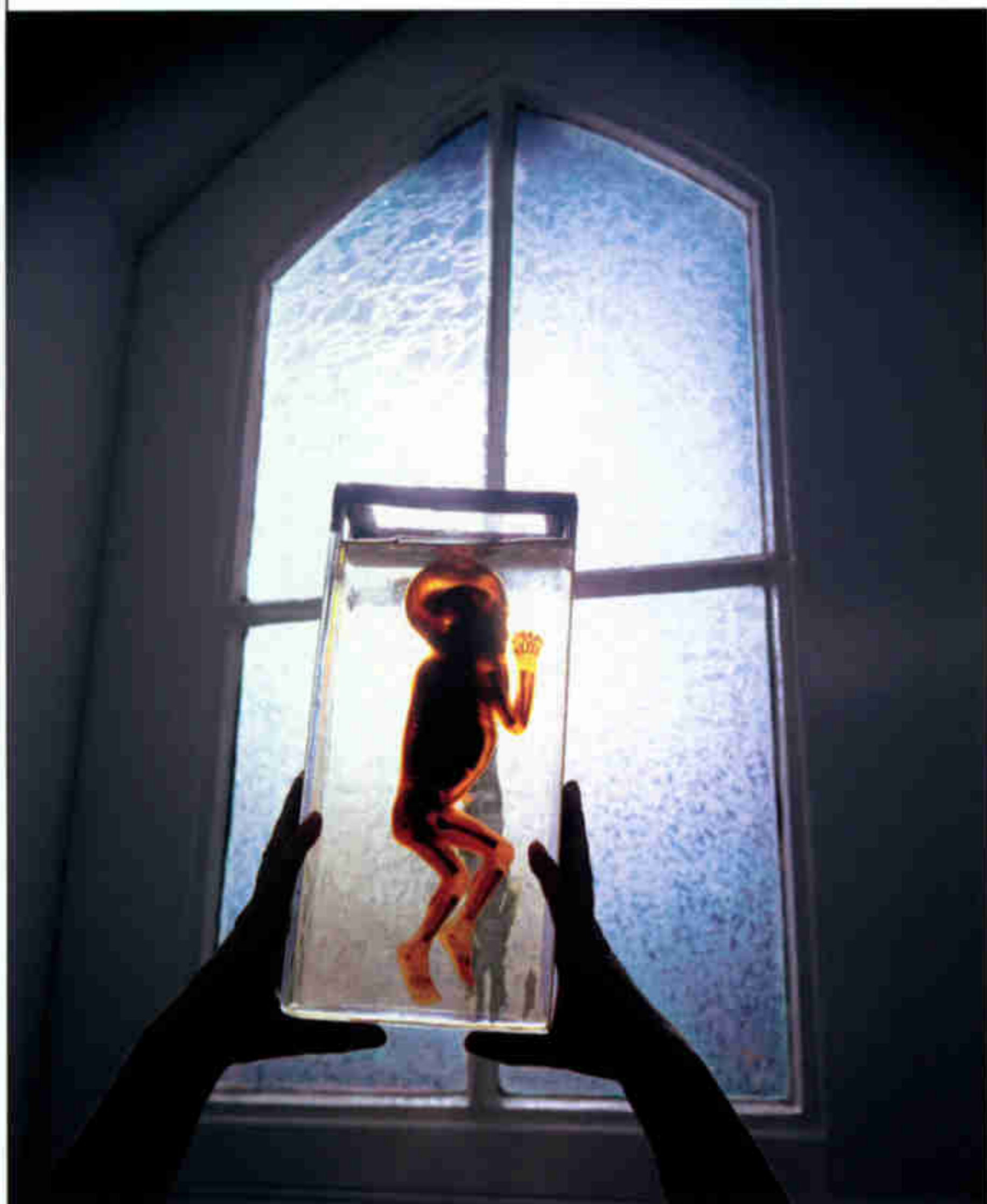
What some see as a shift of research overseas comes in the wake of ethical concerns that have led to U.S. funding restrictions. But many countries, such as Austria and Ireland, have also strongly opposed embryonic work. The loudest no vote booms from the Vatican, which has deemed embryonic research, like abortion,



"a gravely immoral act." Not all Roman Catholics agree: Says Fiorenza DiFranco (above, at far left), whose grandson was baptized at St. Peter's Basilica, "If a therapy can help people, it's not the role of church or government to ban it."

Italian adult stem cell scientist Graziella Pellegrini harbors her own concerns but agrees the research must go on: "If we ban the work," she says, "we risk hypocrisy because we will all gain from what is learned by others." —Jennifer S. Holland

*A five-day-old embryo is smaller than
the period at the end of this sentence.
It has no identifying features
or hints of a nervous system.*



opposing views

For those who believe life begins when sperm and egg collide, the image of an aborted fetus (museum specimen, above) may provoke sadness, pity, or even fiery moral anger. Many abortion

opponents apply the same feelings to embryonic stem cells—condemning research that causes embryos to be destroyed. The only difference between an embryo, a fetus, and a baby, some argue, is time—and all deserve the same protection.

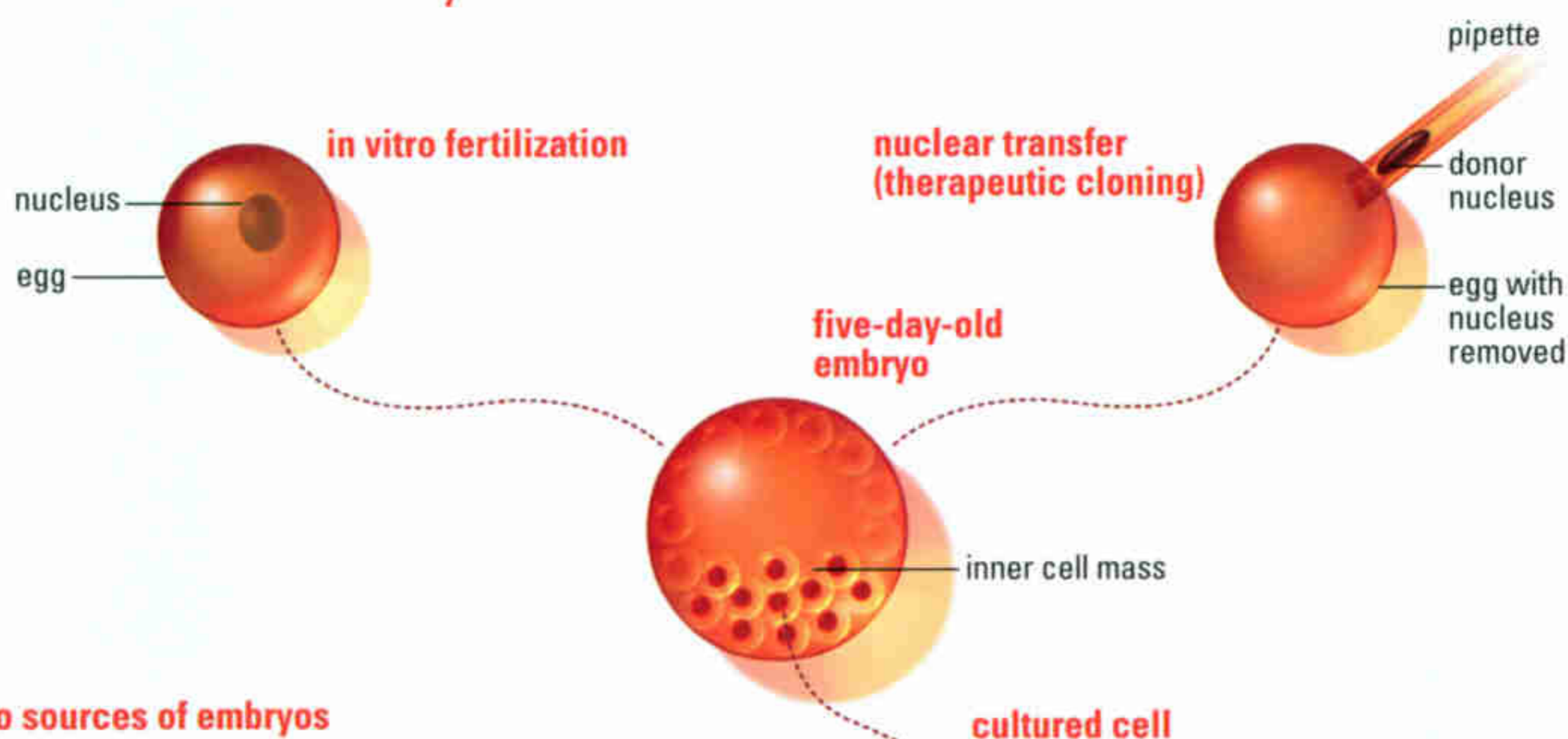
Proponents of embryonic stem cell work present a different picture: Photographed inside the eye of a needle (right) by an electron microscope, a five-day-old embryo is the tiny package from which the controversial cells are usually plucked. Supporters point out that embryos slated for disposal by fertility clinics are a wasted resource, and that the stem cells themselves aren't equipped to develop into a baby if implanted in a uterus. Yet these unspecialized bits have the ability to become any human tissue—a potentially powerful tool for creating healthy tissues and organs to cure deadly diseases.

The public outcry over embryonic research has sent scientists scrambling to find less divisive stem cell sources. Adult stem cells may prove more abundant and malleable than previously thought, but researchers still advocate studying both types.

"It will be difficult to do an end run around the ethical quarrels," says bioethicist Tom Murray, president of the Hastings Center in New York. "We're now having to confront subtle distinctions about life's beginnings that have enormous scientific and religious implications." —J.S.H.



what are embryonic stem cells?



two sources of embryos

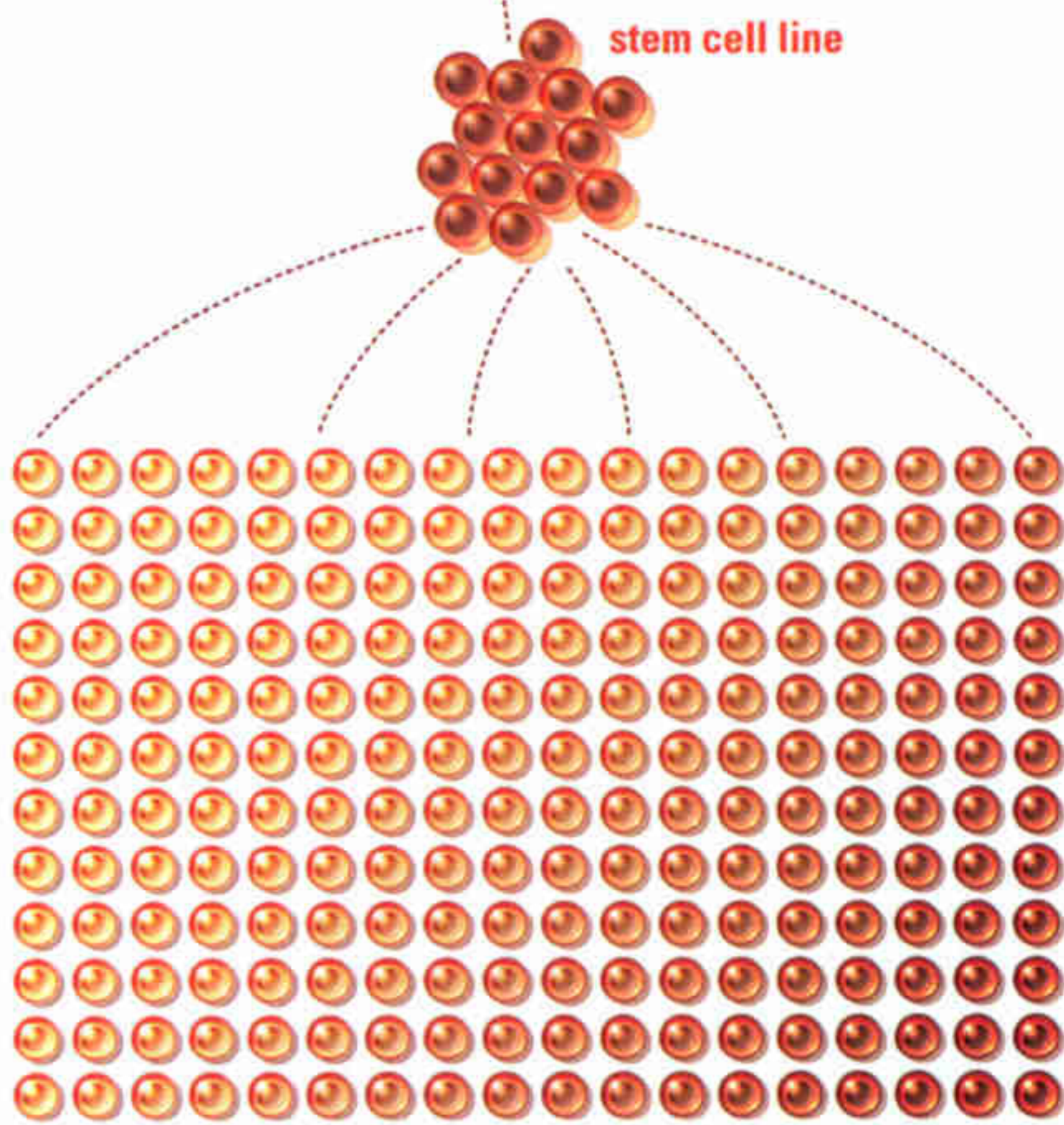
Most embryonic stem cells used for research are extracted from embryos created by in vitro fertilization. But scientists are working on getting cells from embryos produced by therapeutic cloning, in which the nucleus of, say, a skin cell is inserted into an egg whose nucleus has been removed. Either way, after five days scientists transfer the embryo's inner cell mass—with its coveted 40 or so stem cells—to a lab dish lined with feeder cells. As the cells proliferate they are re-plated onto fresh culture dishes. After many months, if the original stem cells have grown into millions of healthy cells without beginning to differentiate into specialized cells, they are referred to as an embryonic stem cell line—capable of reproducing ad infinitum.

turning cells into medicine

Embryonic stem cells' ability to develop into any type of cell—called pluripotency—is both a benefit and a bane to scientists, who must keep harvested cells from maturing and then mold their identities to suit patients' needs.

"One of the greatest challenges in this work is to harness and direct cell differentiation," says Harvard cell biologist Douglas Melton. To tell one stem cell to form blood, another skin, and another liver tissue—what's nature's secret?

Complex combinations of growth factors and chemical and genetic signals drive the process, which researchers are only beginning to pin down. Until they do, embryonic stem cell therapies won't make the leap from lab mice to humans.



can become any of the body's 200-plus cell types

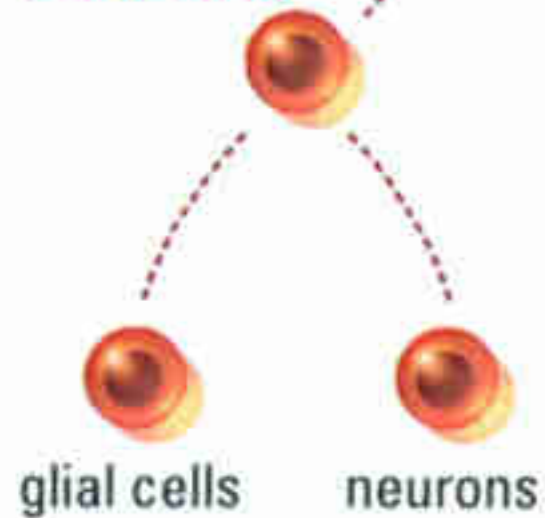
what are adult stem cells?

where they've been found

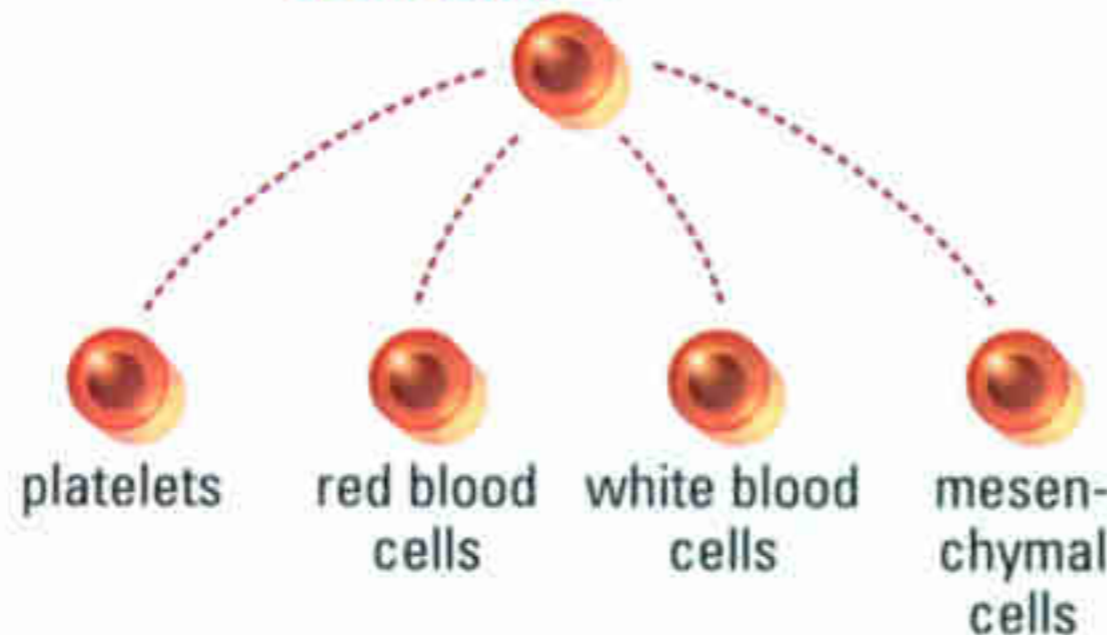
- ⊙ brain
- ⊙ blood
- ⊙ cornea
- ⊙ retina
- ⊙ heart
- ⊙ fat
- ⊙ skin
- ⊙ dental pulp
- ⊙ bone marrow
- ⊙ blood vessels
- ⊙ skeletal muscle
- ⊙ intestines

⊙ umbilical cord

neural stem cell



cord blood stem cell



a more grown-up cell

The adult body has a small number of stem cells in many tissues and organs—where they lie low until activated by illness or injury. Unlike embryonic stem cells, adult stem cells haven't proved able to morph into every kind of cell and may be limited to becoming cell types within their tissue of origin. An adult stem cell in the brain, for example, can become a neuron or glial cell—both neural cells—but not a bone or liver cell.

Similarly stem cells from a newborn's cord blood (considered adult cells because they aren't from embryos) produce only blood cells. Recently, though, cord tissue has been found to contain mesenchymal cells capable of generating bone and cartilage.

In general, adult stem cells are scarcer in the body and harder to culture than embryonic cells, yet large numbers are needed for therapies.

hints of progress

So far only adult stem cells have been tested in humans, though research on both adult and embryonic cells progresses apace as scientists seek treatments for myriad diseases. "This is the century of cells," says Harvard biologist Douglas Melton. Results are preliminary, but they hint at a transformation in medicine. Some disease updates:

heart disease

Adult bone marrow stem cells injected into heart arteries are believed to improve cardiac function in victims of heart attack or heart failure.

leukemia and other cancers

In various studies leukemia patients treated with stem cells from bone marrow and umbilical cord blood emerged free of disease; donor blood stem cells have also reduced non-Hodgkin's lymphoma and pancreatic and ovarian cancer in some patients.

rheumatoid arthritis

Adult stem cells may be helpful in jump-starting repair of eroded cartilage. In human trials, joint pain lessened temporarily after donor stem cell therapy in some patients, and some then responded better to standard drug therapies.

parkinson's disease

Since fetal tissue implants had mixed success in reducing neurological symptoms, some researchers say the best hope is that a patient's own neural stem cells may eventually be coaxed to mature into the dopamine-producing cells needed to treat the disease.

type I diabetes

Basic research is focused on understanding how embryonic stem cells might be trained to become the type of pancreatic islet cells that secrete needed insulin. Recent developments using proteins to spur cell differentiation may speed progress.

Proponents say it's immoral not to use leftover embryos to save lives, while opponents warn of a brave new world of "embryo farms."



donation decision

"If they had a heartbeat, that would make a big difference. But embryos are bunches of cells, and I couldn't throw them down the sink when they could further science," says Marie Dooley, far

left, one of the small percentage of parents who, after undergoing in vitro fertilization (IVF), donated her excess embryos to stem cell research. Dooley conceived two of her three children through IVF before "helping to make history" with her donation to Harvard.

Nearly 400,000 IVF embryos are in storage in the U.S., but less than 3 percent have been donated for research. Almost as many are designated to be discarded each year. Only a fraction of those that do arrive in the labs are suitable for study. —J.S.H.

(Continued from page 7) their reputed mettle.

For days Cedric has endured walloping doses of chemotherapy and radiation in a last-ditch effort to kill every cancer cell in his body. Such powerful therapy has the dangerous side-effect of destroying patients' blood-making stem cells, and so is never applied unless replacement stem cells are available. A search of every bone marrow bank in the country had found no match for Cedric's genetic profile, and it was beginning to look as if he'd run out of time. Then a computer search turned up the frozen cord blood cells at Duke—not a perfect match, but close enough to justify trying.

"Ready?" the nurse asks. Mom and dad, who have spent hours in prayer, nod yes, and a line of crimson wends its way down the tube, bringing the first of about 600 million cells into the boy's body. The video game's sound effects seem to fade behind a muffling curtain of suspense. Although Cedric's balloon-laden room is buoyant with optimism, success is far from certain.

"Grow, cells, grow," Cedric's dad whispers.

His mom's eyes are misty. I ask what she sees when she looks at the cells trickling into her son.

"Life," she says. "It's his rebirth."

IT WILL BE A MONTH before tests reveal whether Cedric's new cells have taken root, but in a way he's lucky. All he needs is a new blood supply and immune system, which are relatively easy to re-create. Countless other patients are desperate to regenerate more than that. Diabetics need new insulin-producing cells. Heart attack victims could benefit from new cardiac cells. Paraplegics might even walk again if the nerves in their spinal cords could regrow.

In a brightly lit laboratory halfway across the country from Cedric's hospital room, three teams of scientists at the University of Wisconsin in Madison are learning how to grow the embryonic stem cells that might make such cures possible. Unlike adult stem cells, which appear to have limited repertoires, embryonic stem cells are pluripotent—they can become virtually every kind of human cell. The cells being nurtured here are direct descendants of the ones James Thomson isolated seven years ago.

For years Thomson and his colleagues have been expanding some of those original stem cells into what are called stem cell lines—colonies of millions of pluripotent cells that keep

proliferating without differentiating into specific cell types. The scientists have repeatedly moved each cell's offspring to less crowded laboratory dishes, allowing them to divide again and again. And while they worked, the nation struggled to get a handle on the morality of what they were doing.

It took almost two years for President Bill Clinton's administration to devise ethics guidelines and a system for funding the new field. George W. Bush's ascension prevented that plan from going into effect, and all eyes turned to the conservative Texan to see what he would do. On August 9, 2001, Bush announced that federal funds could be used to study embryonic stem cells. But to prevent taxpayers from becoming complicit in the destruction of human embryos, that money could be used only to study the stem cell lines already in the works as of that date—a number that, for practical reasons, has resulted in about two dozen usable lines. Those wishing to work with any of the more than a hundred stem cell lines created after that date can do so only with private funding.

Every month scientists from around the world arrive in Madison to take a three-day course in how to grow those approved cells. To watch what they must go through to keep the cells happy is to appreciate why many feel hobbled by the Bush doctrine. For one thing—and for reasons not fully understood—the surest way to keep these cells alive is to place them on a layer of other cells taken from mouse embryos, a time-consuming requirement. Hunched over lab benches, deftly handling forceps and pipettes with blue latex gloves, each scientist in Madison spends the better half of a day dissecting a pregnant mouse, removing its uterus, and prying loose a string of embryos that look like little red peas in a pod. They then wash them, mash them, tease apart their cells, and get them growing in lab dishes. The result is a hormone-rich carpet of mouse cells upon which a few human embryonic stem cells are finally placed. There they live like pampered pashas.

If their scientist-servants don't feed them fresh liquid nutrients at least once a day, the cells die of starvation. If each colony is not split in half each week, it dies from overcrowding. And if a new layer of mouse cells is not prepared and provided every two weeks, the stem cells grow into weird and useless masses that finally die.



By contrast, scientists working with private money have been developing embryonic stem cell lines that are hardier, less demanding, and not dependent on mouse cells. Bypassing the use of mouse cells is not only easier, but it also eliminates the risk that therapeutic stem cells might carry rodent viruses, thereby potentially speeding their approval for testing in humans.

Here in the Madison lab, scientists grumble about how fragile the precious colonies are. "They're hard to get to know," concedes Leann Crandall, one of the course's instructors and a co-author of the 85-page manual on their care and feeding. "But once you get to know them, you love them. You can't help it. They're so great. I see so many good things coming from them."

A FEW AMERICAN scientists are finding it is easier to indulge their enthusiasm for stem cells overseas. Scores of new embryonic stem cell lines have now been created outside the U.S., and many countries are aggressively seeking to spur the development of therapies using these cells, raising a delicate question: Can the nation in which embryonic stem cells were discovered maintain its initial research lead?

"I know a lot of people back in the U.S. who would like to move into embryonic stem cell work but who won't because of the political uncertainties," says Stephen Minger, director of the Stem Cell Biology Laboratory at King's College in London, speaking to me in his cramped and cluttered office. "I think the United States is in real danger of being left behind."

Minger could be right. He is one of at least two high-profile stem cell scientists to move from the U.S. to England in the past few years, something less than a brain drain but a signal, perhaps, of bubbling discontent.

fixing broken hearts

Adult stem cells from Arno Christleit's own hip helped repair his ailing heart. In a German study Christleit and other heart attack patients had cells from their bone marrow injected into their coronary arteries. "Cardiac function increased significantly," says Helmut Drexler of the Medical University of Hannover. Whether the cells actually convert to cardiac cells isn't clear, but their presence seems to power the repair.

The research climate is good here, says Minger. In 2003 his team became the first in the U.K. to grow colonies of human embryonic stem cells, and his nine-person staff is poised to nearly double. He's developing new growth culture systems that won't rely on potentially infectious mouse cells. He's also figuring out how to make stem cells morph into cardiac, neural, pancreatic, and retinal cells and preparing to test those cells in animals. And in stark contrast to how things are done in the U.S., Minger says, he's doing all this with government support—and oversight.

The Human Fertilisation and Embryology Authority (HFEA), the government agency that has long overseen U.K. fertility clinics, is now also regulating the country's embryonic stem cell research. In closed-door meetings a committee of 18 people appointed by the National Health Service considers all requests to conduct research using embryos. The committee includes scientists, ethicists, lawyers, and clergy, but the majority are lay people representing the public.

To an American accustomed to high security and protesters at venues dealing regularly with embryo research, the most striking thing about the HFEA's headquarters in downtown London is its ordinariness. The office, a standard-issue warren of cubicles and metal filing cabinets, is on the second floor of a building that also houses the agency that deals with bankruptcy. I ask Ross Thacker, a research officer at the authority, whether the HFEA is regularly in need of yellow police tape to keep protesters at bay.

"Now that you mention it," he says, "there was a placard holder outside this morning . . ."

Aha!

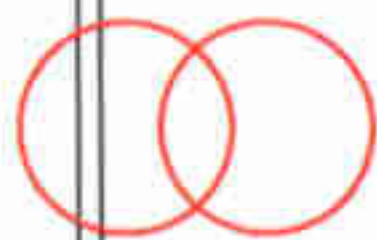
". . . but he was protesting something about the insolvency office."

Thacker politely refrains from criticizing U.S. policy on embryo research, but he clearly takes pride in the orderliness of the British system. The committee has approved about a dozen requests to create stem cell lines in the past 18 months, increasing the number of projects to 35. Most were relatively routine—until a strong-willed fertility doctor named Alison Murdoch decided to ask for permission to do something nobody had done before: create cloned human embryos as sources of stem cells.

As controversial as embryonic stem cell research can be, cloning embryos to produce those stem cells is even

(Continued on page 22)

Many suspect that new kinds of adult stem cells may be found that are as versatile as those found in embryos.



seeing is believing

When it comes to stem cell therapies already boasting success, the eyes have it. Graziella Pellegrini, Michele De Luca, and colleagues of the Italian Eye Bank Foundation are able to use

adult stem cells from a patient's good eye to help repair a bad one (right). Harvested from a part of the cornea called the limbus, the cells are coaxed to form a membrane that can be transplanted to the problem spot—here a cornea scarred from a chemical burn.

Like the body mending a scraped knee, a hefty dose of stem cells enables the eye to grow fresh, healthy tissue. Such tissue engineering is an improvement over corneal grafts from cadavers, which carry a risk of rejection.

To understand the precise mechanisms driving successful eye repairs, Michael Young and Henry Klassen of the Schepens Eye Research Institute at Harvard have enlisted the help of some unusual pigs. By introducing a fluorescent gene from a jellyfish, Randall Prather at the University of Missouri created pigs that glow green—providing the eye researchers with the perfect cellular marker. When Young and his co-workers implant retinal cells from the fluorescent animals into normal-colored pigs with retinal injury, they can track the green cells and monitor their actions.

“What they do is find the retinal injury and repair it,” Young says. “It seems the damage instructs the cells, tells them what to do.”

The technique is extremely delicate, requiring keyhole surgery through the back of the eye. But in controlled studies the treatment has given some animals a new view of the world. —J.S.H.





*Under the right conditions
the cells can grow into blobs of heart
muscle that beat in spooky
unison in laboratory dishes.*

recipe for reconstruction

It's a long strange trip to get stem cell research from freezer to fruition. One goal for Anthony Atala at Wake Forest University's Institute for Regenerative Medicine is to engineer human organs, which he likens to baking a cake. For a homegrown bladder (right), take a thumbnail-size biopsy of the patient's own organ, harvest and nurture its cells, then slather the slurry onto a collagen scaffold and watch it grow. The scaffold beneath eventually disintegrates.

Perfecting replacement organs is a tall order, though, and so far none are up to snuff for transplant. The body can absorb only a small amount of tissue without blood vessels—about the size of a pencil eraser, says Atala. Another problem: Sometimes an adult's diseased organ can't provide sufficient or healthy enough cells to seed such a surrogate.

Embryonic stem cells are one possible alternative, kept on ice in Atala's lab (left) with vials of other research ingredients—including serum laced with growth factors designed to spur the cells to become specific tissue types.

Embryonic cells' splendid ability to metamorphose into various cell



types is also their limitation: Not surprisingly, bladders infused with bone from stem cells gone awry aren't clinically useful, says Jason Hipp, one of some 60 institute researchers working on how to keep the cells from going haywire.

Meanwhile, Atala and his team are already sculpting tissues and whole organs—from blood vessels to livers—for future clinical trials. "The goal," he says, "is to make as many as we can, eventually replacing diseased parts with functioning ones." —J.S.H.

(Continued from page 17) thornier. Much of the world became familiar with cloning in 1997, when scientists announced they'd cloned a sheep named Dolly. The process involves creating an animal not from egg and sperm but by placing the nucleus of a cell inside an egg that's had its nucleus removed. It's since been used to replicate mice, rabbits, cats, and cattle, among others.

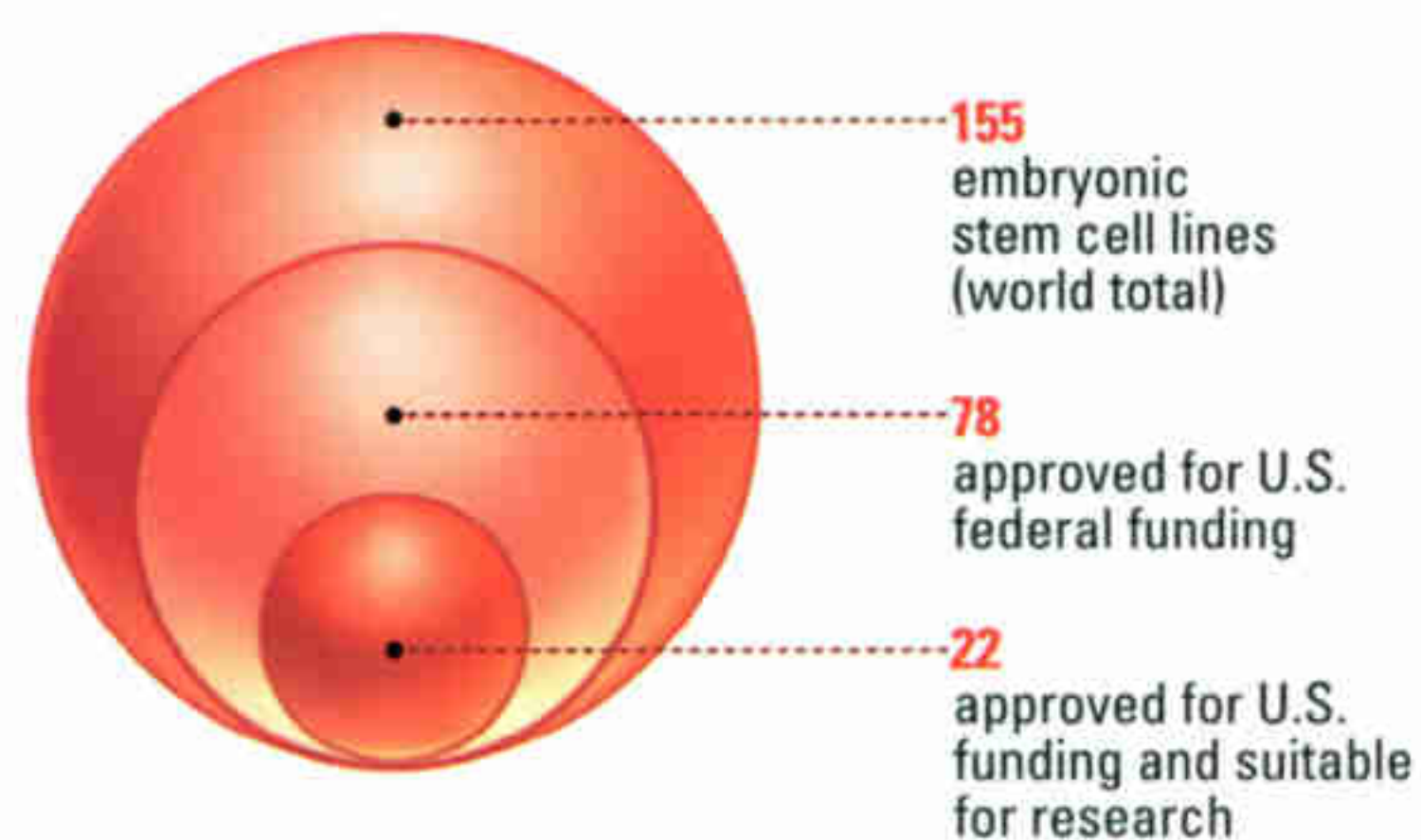
As in many other countries and a few U.S. states, it's illegal in the U.K. to create cloned human babies (called reproductive cloning), because of concerns that clones may be biologically abnormal and because of ethical issues

argued, by watching how the disease damages nerve and muscle cells grown from those stem cells, and then testing various drugs on them. It's the kind of experiment that could never be done in a person with the disease.

The HFEA deliberated for five months before giving Murdoch permission to make human embryo clones in her lab at the Centre for Life in Newcastle, a sprawling neon-illuminated complex of buildings that strikes a decidedly modern note in the aging industrial hub. But there was a catch: It takes an egg to make a clone. And under the terms of HFEA approval, Murdoch is

how many lines exist?

Since President Bush banned U.S. government funding for the study of embryonic stem cell lines created after August 9, 2001, the number of lines worldwide has doubled, though reliable data are hard to come by. Biologist Douglas Melton of Harvard says many lines approved for federal dollars "are old fuddy-duddies that have lost potential" because of how they were cultured. "That's why we need new lines," he says.



surrounding the creation of children who would be genetic replicas of their one-and-only "parent."

In 2001 the British Parliament made it legal to create cloned human embryos—as opposed to babies—for use in medical research (called therapeutic cloning). Still, no one on the HFEA was completely comfortable with the idea. The fear was that some rogue scientist would take the work a step further, gestate the embryo in a woman's womb, and make the birth announcement that no one wanted to hear.

But Murdoch, of the University of Newcastle upon Tyne, made a compelling case. If replacement tissues grown from stem cells bore the patient's exact genetic fingerprint, they would be less likely to be rejected by a patient's immune system, she told the committee. And what better way to get such a match than to derive the cells from an embryo cloned from the patient's own DNA? Disease research could also benefit, she said. Imagine an embryo—and its stem cells—cloned from a person with Lou Gehrig's disease, a fatal genetic disorder that affects nerves and muscles. Scientists might learn quite a bit, she

allowed to use only those eggs being disposed of by the center's fertility clinic after they failed to fertilize when mixed with sperm.

It's not a perfect arrangement, Murdoch says. After all, eggs that have failed to fertilize are almost by definition of poor quality. "They're not brilliant," she says of the eggs. "But the U.K. has decided at the moment that these are the most ethical sort to use. So that's really all we can work with." As of April the group hadn't managed to clone any embryos, despite numerous attempts.

No such obstacle faced Woo-Suk Hwang and his colleagues at Seoul National University in February 2004 when they became the world's first to clone human embryos and extract stem cells from them. The South Korean government allows research on human embryos made from healthy eggs—in this case, donated by 16 women who took egg-ripening hormones.

Cloning is an arduous process that requires great patience and almost always ends in failure as cells burst, tear, or suffer damage to their DNA, but the Koreans are expert cloners, their skills sharpened in the country's state-funded

livestock-cloning enterprise. In Hwang's lab alone, technicians produce more than 700 cloned pig or cattle embryos every day, seven days a week, in a quest to produce livestock with precise genetic traits. "There is no holiday in our lab," Hwang told me with a smile.

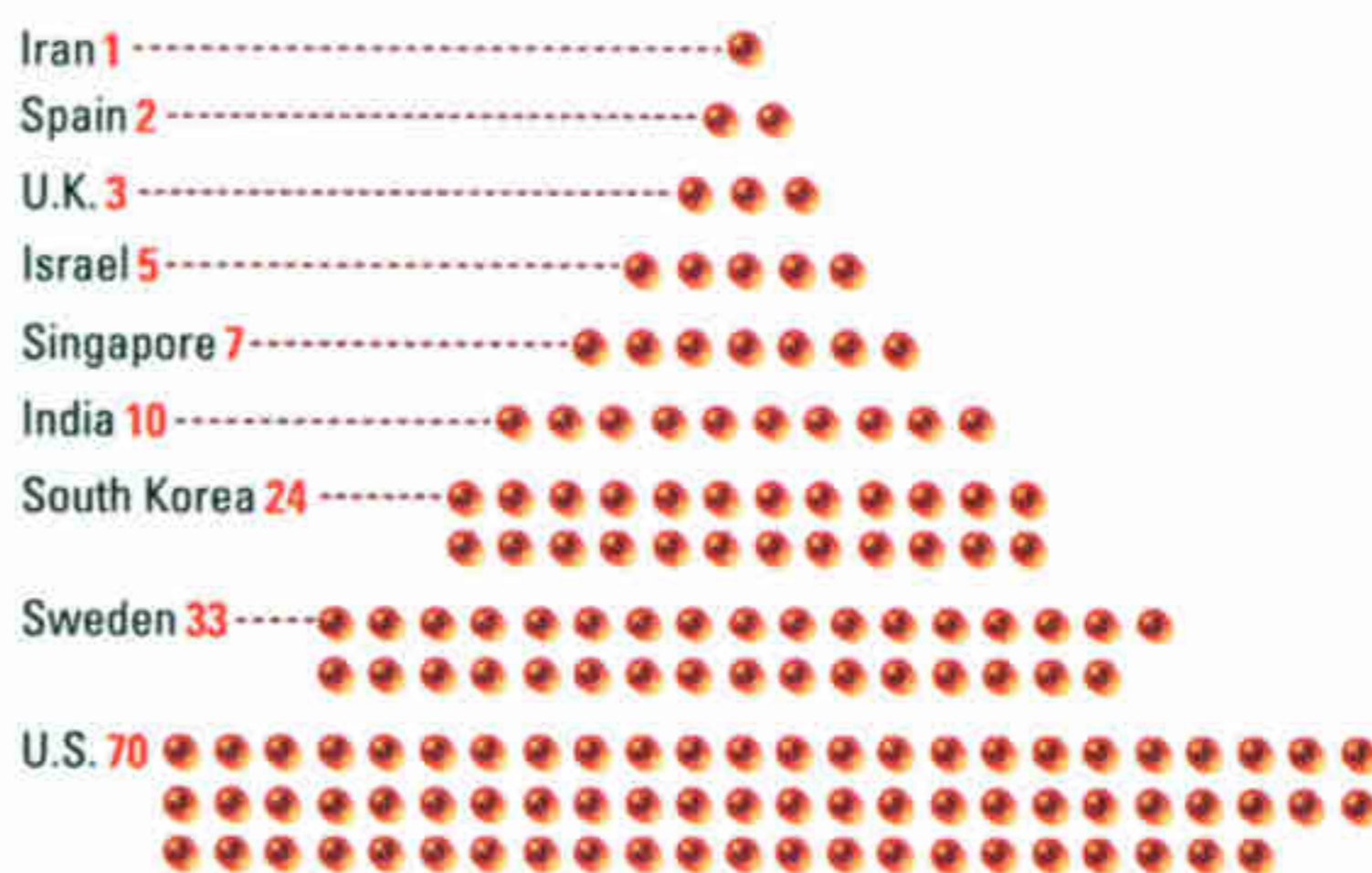
But there is something else that gives Koreans an edge over other would-be cloners, Hwang says. "As you know, Asian countries use chopsticks, but only the Koreans use steel chopsticks," he explains. "The steel ones are the most difficult to use. Very slippery." I look at him, trying to tell if he's kidding. A lifetime of using steel chop-

Singapore stands out like a post-modern mirage. The towering laboratory buildings of its Biopolis were created in 2001 to jump-start Singapore's biotechnology industry. Like a scene from a science fiction story, it features futuristic glass-and-metal buildings with names like Matrix, Proteos, and Chromos, connected by skywalks that facilitate exchanges among researchers.

Academic grants, corporate development money, laws that ban reproductive cloning but allow therapeutic cloning, and a science-savvy workforce are among the lures attracting stem cell researchers and entrepreneurs. Even Alan

where are they?

The U.S. still leads in the number of embryonic stem cell lines, despite the restrictions on federal funding; states such as California are investing in research to create new and better lines. But the U.K. and rising Asian economies, such as South Korea and Singapore, are pouring funds into their research labs in an effort to catch up—with government oversight and financial support.



sticks makes Koreans better at manipulating tiny eggs? "This is not simply a joke," he says.

Time will tell whether such skill will be enough to keep Korea in the lead as other countries turn to cloning as a source of stem cells. The competition will be tough. China has pioneered a potentially groundbreaking technique that produces cloned human embryos by mixing human skin cells with the eggs of rabbits, which are more easily obtained than human eggs. A few privately funded researchers in the U.S. are also pursuing therapeutic cloning.

YET THE BIGGEST COMPETITION in the international race to develop stem cell therapies may ultimately come from one of the smallest of countries—a tiny nation committed to becoming a stem cell superpower. To find that place, one need only track the migration patterns of top scientists who've been wooed there from the U.S., Australia, even the U.K. Where they've been landing, it turns out, is Singapore.

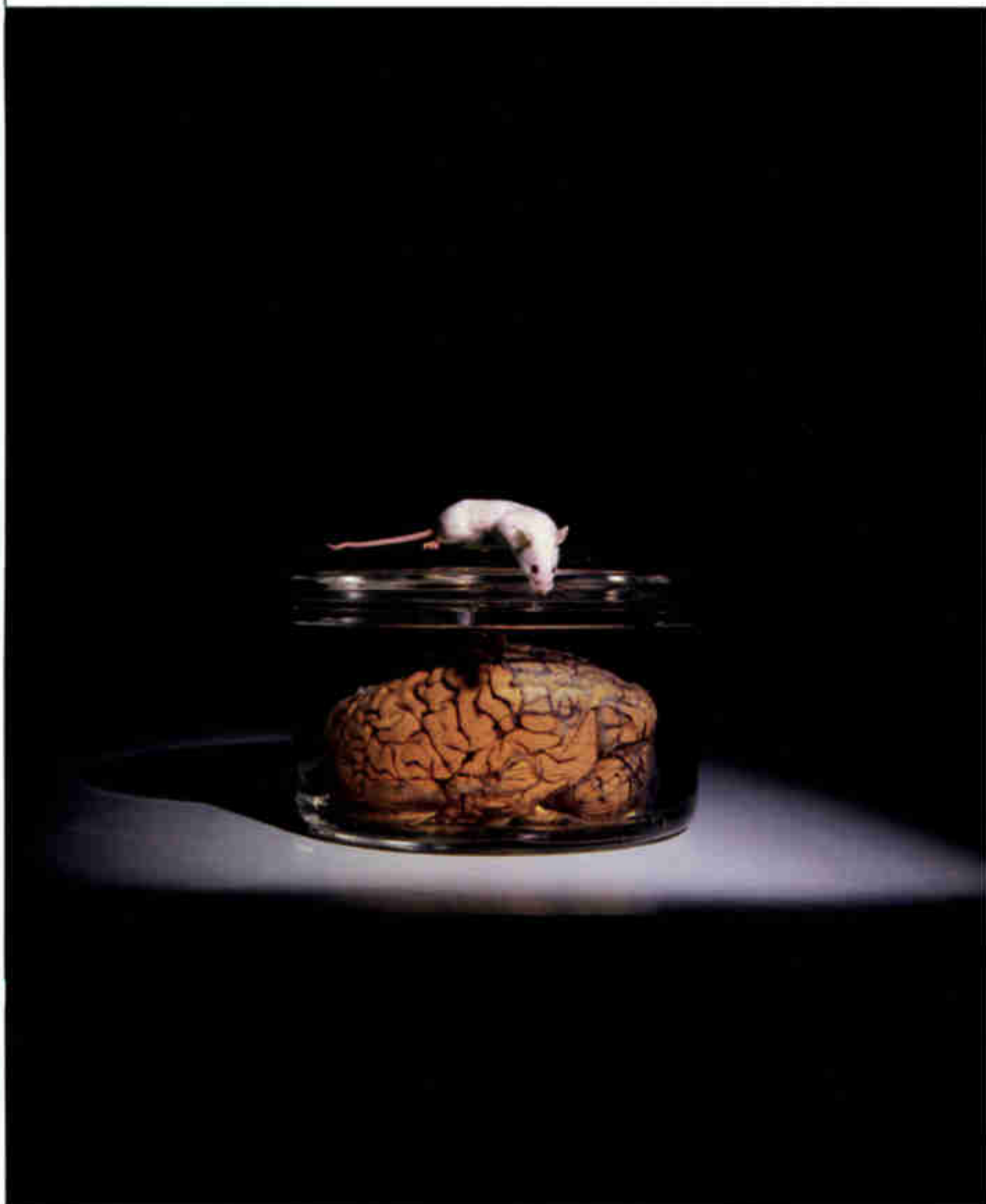
Amid the scores of small, botanically rich but barely inhabited islands in the South China Sea,

Colman—the renowned cloning expert who was part of the team that created Dolly, the cloned sheep—has taken leave of his home in the U.K. and become the chief executive of ES Cell International, one of a handful of major stem cell research companies blossoming in Singapore's fertile environs.

"You don't have to fly from New York to San Diego to see what's going on in other labs," says Robert Klupacs, the firm's previous CEO. "You just walk across the street. Because Singapore is small, things can happen quickly. And you don't have to go to Congress at every turn."

The company's team of 36, with 15 nationalities represented, has taken advantage of that milieu. It already owns six stem cell lines made from conventional, noncloned embryos that are approved for U.S. federal funding. Now it is perfecting methods of turning those cells into the kind of pancreatic islet cells that diabetics need, as well as into heart muscle cells that could help heart attack patients. The company is developing new, mouse-free culture systems and sterile production facilities to satisfy regulators such as the

*Recipients of stem cell transplants
are the world's first generation of
regenerated people, a seamless
blend of old and new.*



mending the mind

"After two strokes and brain damage, I considered calling [assisted-suicide advocate] Dr. Kevorkian," says recovering lupus patient Katherine Hammons (comforting a fellow patient,

right). Instead she entered an ongoing study in which oncologist Ann Traynor, now at the University of Massachusetts, treats lupus patients with stem cells from their own bone marrow. Six years after therapy, Hammons's progress has exceeded expectations: Even

damage previously thought permanent is healing. "I'm reborn," Hammons says. "I've crossed Kevorkian off my list."

More recently Traynor treated Margaret Laperle (wired for an electroencephalogram, right) who is just beginning to recover from the lupus-related psychosis that stalled her own medical career. "It shows that even people with tremendous disability can regain function," says Traynor, who reports that 75 percent of her study patients remain in remission two to eight years after treatment.

Meanwhile scientists at Stem-Cells, Inc. in Palo Alto are using mice (left) to test the limits of human brain cells—with mind-boggling results. When neuronal stem cells from a human fetus were transplanted into a mouse brain, they didn't just survive; they started working right alongside the mouse's own neurons.

"These cells might not only repair local lesions, but also offer protection from progressive neurodegenerative diseases," says company co-founder Irving Weissman. The results inch scientists closer to treating Parkinson's, brain-damaging genetic disorders, and perhaps spinal cord injuries, he says. —J.S.H.



U.S. Food and Drug Administration. It hopes to begin clinical tests in humans by 2007.

Despite its research-friendly ethos—and its emphasis on entrepreneurial aspects of stem cell science—Singapore doesn't want to be known as the world's "Wild West" of stem cell research. A panel of scientific and humanitarian representatives spent two years devising ethical guidelines, stresses Hwai-Loong Kong, executive director of Singapore's Biomedical Research Council. Even the public was invited to participate, Kong says—an unusual degree of democratic input for the authoritarian island nation.



better than bone marrow

His sister Eusnel's umbilical cord blood saved Neel Padonou from the ravages of sickle-cell anemia. More easily tolerated and less risky for both donor and recipient than bone marrow, cord blood is one in a growing line of so-called adult stem cell therapies now in clinical use. But embryonic stem cells may not be far behind: Researchers hope to test them in humans for the first time as early as next year.

The country's policies represent a "judicious balance," he says, that has earned widespread public support.

Widespread, perhaps, but not universal. After my conversation with Kong, a government official offered me a ride to my next destination. As we approached her parked car, she saw the surprise on my face as I read the bumper sticker on her left rear window: "Embryos—Let Them Live. You Were Once an Embryo Too!"

"I guess this is not completely settled," I said. "No," she replied, choosing not to elaborate.

THAT BUMPER STICKER made me feel strangely at home. I am an American, after all. And no country has struggled more with the moral implications of embryonic stem cell research than the U.S., with its high church attendance rates and pockets of skepticism for many things scientific. That struggle promises to grow in the months and years ahead. Many in Congress want to ban the cloning of human embryos, even in those states where it is currently legal and being pursued with private funding. Some states have already passed legislation banning various kinds of embryo research. And federally backed scientists are sure to become increasingly frustrated as the handful of cell colonies they're allowed to work with becomes an ever smaller fraction of what's available.

Yet one thing I've noticed while talking to stem cell experts around the world: Whenever I ask who is the best in the field, the answers are inevitably weighted with the names of Americans. The work of U.S. researchers still fills the pages of the best scientific journals. And while federal policy continues to frustrate them, they are finding some support. Following the lead of California, which has committed 300 million dollars a year for embryonic stem cell research for the next decade, several states are pushing initiatives to fund research, bypassing the federal restrictions in hopes of generating well-paying jobs to boost their economies. Moves like those prompt some observers to predict that when all is said and done, it will be an American team that wins the race to create the first FDA-approved embryonic stem cell therapy.

Tom Okarma certainly believes so, and he intends to be that winner. Okarma is president of Geron, the company in Menlo Park, California, that has been at the center of the embryonic

stem cell revolution from the beginning. Geron financed James Thomson's discovery of the cells in Wisconsin and has since developed more than a dozen new colonies. It holds key patents on stem cell processes and products. And now it's laying the groundwork for what the company hopes will be the first controlled clinical trials of treatments derived from embryonic stem cells. Moreover, while others look to stem cells from cloned embryos or newer colonies that haven't come into contact with mouse cells, Okarma is looking no further than the very first colonies of human embryonic stem cells ever grown: the ones Thomson nurtured back in 1998. That may seem surprising, he acknowledges, but after all these years, he knows those cells inside out.

"We've shown they're free of human, pig, cow, and mouse viruses, so they're qualified for use in humans," Okarma says at the company's headquarters. Most important, Geron has perfected a system for growing uniform batches of daughter cells from a master batch that resides, like a precious gem, in a locked freezer. The ability to produce a consistent product, batch after batch, just as drug companies do with their pills is what the FDA wants—and it will be the key to success in the emerging marketplace of stem cell therapies, Okarma says. "Why do you think San Francisco sourdough bread is so successful?" he asks. "They've got a reliable sourdough culture, and they stick with it."

Geron scientists can now make eight different cell types from their embryonic lines, Okarma says, including nerve cells, heart cells, pancreatic islet cells, liver cells, and the kind of brain cells that are lost in Parkinson's disease. But what Geron wants most at this point is to develop a treatment for spinal cord injuries.

Okarma clicks on a laptop and shows me a movie of white rats in a cage. "Pay attention to the tail and the two hind legs," he says. Two months before, the rats were subjected to spinal cord procedures that left their rear legs unable to support their weight and their tails dragging along the floor. "That's a permanent injury," he says. He flips to a different movie: white rats again, also two months after injury. But these rats received injections of a specialized nervous system cell grown from human embryonic stem cells. They have only the slightest shuffle in their gait. They hold their tails high. One even stands upright on its rear legs for a few moments.

"It's not perfect," Okarma says. "It's not like we've made a brand new spinal cord." But tests show the nerves are regrowing, he says. He hopes to get FDA permission to start testing the cells in people with spinal cord injuries in 2006.

THOSE EXPERIMENTS WILL surely be followed by many others around the world, as teams in China, the U.K., Singapore, and other nations gain greater control over the remarkable energy of stem cells. With any luck the political and ethical issues may even settle down. Many suspect that with a little more looking, new kinds of stem cells may be found in adults that are as versatile as those in embryos.

At least two candidates have already emerged. Catherine Verfaillie, a blood disease specialist at the University of Minnesota, has discovered a strange new kind of bone marrow cell that seems able to do many, and perhaps even all, the same things human embryonic stem cells can do. Researchers at Tufts University announced in February that they had found similar cells. While some scientists have expressed doubts that either kind of cell will prove as useful as embryonic ones, the discoveries have given birth to new hopes that scientists may yet find the perfect adult stem cell hiding in plain sight.

Maybe Cedric Seldon himself will discover them. The stem cells he got in his cord blood transplant did the trick, it turns out. They took root in his marrow faster than in anyone his doctors have seen. "Everyone's saying, 'Oh my God, you're doing so well,'" his mother says.

That makes Cedric part of the world's first generation of regenerated people, a seamless blend of old and new—and, oddly enough, of male and female. His stem cells, remember, came from a girl, and they've been diligently churning out blood cells with two X chromosomes ever since. It's a detail that will not affect his sexual development, which is under the control of his hormones, not his blood. But it's a quirk that could save him, his mother jokes, if he ever commits a crime and leaves a bit of blood behind. The DNA results would be unambiguous, she notes correctly. "They'll be looking for a girl." □

STEM CELL DIVIDE Where do you stand on the future of stem cell research? Join our discussion, view additional images by photographer Max Aguilera-Hellweg, and find useful links to more information at nationalgeographic.com/magazine/0507.





A man of towering height and ambition, Zheng He led one of the grandest trading fleets the world has ever known. In the early 15th century his vast floating city of hundreds of ships spread Chinese influence and gathered knowledge and wealth from Indochina to the coast of Africa. With Zheng as its maritime architect, China became a superpower.

ART BY HONGNIAN ZHANG

*Six hundred years ago
China's Admiral **Zheng He**
led a mighty fleet on the first
of seven voyages
that reshaped an empire.*

China's Great Armada

By Frank Viviano
Photographs by Michael Yamashita





SRI LANKA Dancers at a festival in Kandy celebrate a treasured relic, a sacred tooth of Buddha that Zheng's ships may once have taken to China. The fleet traded in gem-rich Sri Lanka, then as now riven by conflict between Tamil Hindus and Sinhalese Buddhists. After being attacked, Zheng's men defeated forces of a Buddhist rebel leader here in 1411, the fleet's only major land battle.

Viewed from the rocky outcropping of Dondra Head at the southernmost tip of Sri Lanka, the first sighting of the Ming fleet is a massive shadow on the horizon. As the shadow rises, it breaks into a cloud of tautly ribbed sail, aflame in the tropical sun. With relentless determination, the cloud draws ever closer, and in its fiery embrace an enormous city appears. A floating city, like nothing the world has ever seen before. No warning could have prepared officials, soldiers, or the thunderstruck peasants who stand atop Dondra Head for the scene that unfolds below them. Stretched across miles of the Indian Ocean in terrifying majesty is the armada of Zheng He, admiral of the imperial Ming navy.

Exactly 600 years ago this month the great Ming armada weighed anchor in Nanjing, on the first of seven epic voyages as far west as Africa—almost a century before Christopher Columbus’s arrival in the Americas and Vasco da Gama’s in India. Even then the European expeditions would seem paltry by comparison: All the ships of Columbus and da Gama combined could have been stored on a single deck of a single vessel in the fleet that set sail under Zheng He.

Its commander was, without question, the most towering maritime figure in the 4,000-year annals of China, a visionary who imagined a new world and set out consciously to fashion it. He was also a profoundly unlikely candidate for admiral in anyone’s navy, much less that of the Dragon Throne.

The greatest seafarer in China’s history was raised in the mountainous heart of Asia, several weeks’ travel from the closest port. More improbable yet, Zheng was not even Chinese—he was by origin a Central Asian Muslim. Born Ma He, the son of a rural official in the Mongol province of Yunnan, he had been taken captive

as an invading Chinese army overthrew the Mongols in 1382. Ritually castrated, he was trained as an imperial eunuch and assigned to the court of Zhu Di, the bellicose Prince of Yan.

Within 20 years the boy who had writhed under Ming knives had become one of the prince’s chief aides, a key strategist in the rebellion that made Zhu Di the Yongle (Eternal Happiness) emperor in 1402. Renamed Zheng after his exploits at the battle of Zhenglunba, near Beijing, he was chosen to lead one of the most powerful naval forces ever assembled.

Six centuries later I left China with photographer Michael Yamashita in search of Zheng He’s legacy, a 10,000-mile journey that would carry us from Yunnan to Africa’s Swahili coast. Along the way I came to feel that I had found the man himself.

The voyages’ initial impulse was bluntly elemental: the Yongle emperor’s colossal ambition. Its spirit is best captured at the ancient Yangshan quarries in Jiangsu Province, 15 miles from Nanjing.

Mike and I were among Yangshan’s few visitors on a wet May afternoon, wandering



Shown on a mural in his landlocked hometown of Kunyang, China, Zheng, a Central Asian Muslim who was captured and castrated by the Chinese, didn't seem destined for fame.

blindly through a maze of narrow canyons, when a gigantic monolith suddenly loomed ahead of us in the mist. It was a gravestone the size of a skyscraper, carved out of an abrupt cliff—the base of a planned 25-story memorial tablet that Zhu Di commissioned for the tomb of his father, Zhu Yuanzhang, the Hongwu emperor, founder of the Ming dynasty. Eventually it had to be abandoned in its granite niche because, at an estimated 34,000 tons, the completed monument would have been impossible to move.

Zhu's tablet was the funereal equivalent of a maritime buildup so massive, so megalomaniac in its dimensions, that until recently most scholars dismissed them as sheer myth. In 1962 that skepticism was wrenched into dazed astonishment. At the bottom of a muddy trench on the south bank of the Yangtze River in Nanjing, workers unearthed a wooden steering post 36 feet long with evidence of an attached

rudder whose surface area worked out to a mind-boggling 452 square feet—big enough to turn a vessel the size of the legendary *baochuan*, meaning “treasure ships,” of the Ming armada.

The fleet commanded by Zheng He counted as many as 62 of these gargantuan vessels, which some nautical experts believe may have measured up to 400 feet in length and 170 feet across the beam—with nine masts, 50,000-square-foot main decks, and a displacement of at least 3,000 tons, ten times the size of Vasco da Gama's flagship. Scholars disagree on the *baochuan*'s actual size, but even at far more modest estimates they were surely the largest wooden ships ever launched.

The *baochuan* were escorted by 370-foot-long, eight-masted “galloping-horse ships,” the swiftest in the fleet, 280-foot supply ships, 240-foot troop transports, and agile 180-foot combat junks, according to interpretations of Ming sources. More than 300 vessels are believed to have sailed on Zheng's main voyages to what the Chinese call *Xi Yang*, the Western Ocean. The ships were manned by nearly 30,000 sailors and marines, seven grand eunuchs and hundreds of other Ming officials, 180 physicians, five astrologers, and ranks of geomancers, sailmakers, herbalists, blacksmiths, carpenters, tailors, cooks, accountants, merchants, and interpreters.

These are extraordinary numbers, but perfectly in step with the prevailing ethos of Zhu Di's reign. Vast expansions of the Grand Canal and the Great Wall were completed during the Yongle decades, along with hundreds of temples and palaces. In the years between Zheng He's second and sixth expeditions (1409-1421), the emperor would order the imperial capital itself moved 600 land miles to the north, from Nanjing to Beijing, commissioning the monumental Forbidden City at its heart and a sprawling metropolis to surround it.

It was against this frenetic background that Admiral Zheng He received his sailing orders on July 11, 1405.

He was, according to family sources, as outsized as his ships: seven feet tall, with a waist five feet in circumference, “and a voice as loud as a huge bell.” Even allowing for exaggeration, by all accounts Zheng was an imposing man.

But it was not the admiral's physical stature that seized my attention early on. It was his surprising faith in the virtue of humility,

The voyages were a floating encyclopedia-in-progress for Ming China—a compilation of all worth knowing between Nanjing and Africa.

expressed on a trip back to Kunyang, his Yun-nan Province hometown, just one month before the first voyage. The trip's purpose was to erect a stone pillar, inscribed with an epitaph, over the grave of his father, Ma Haji.

Ma Haji had died on August 12, 1382, at the age of 37, a casualty of the same Ming invasion that left Ma He a eunuch. The elder Ma, his famous son declares in the epitaph, was moved neither by power nor by position. On the contrary, "he was content as an ordinary commoner" but also insistently brave and decisive in that ordinary life. "When he encountered the unfortunate—including widows, orphans, and others with no one to rely on, he routinely [offered them] protection and aid."

Ma Haji, in short, is a paragon of instinctive nobility—not the nobility of an emperor or admiral but someone who was "by nature . . . especially fond of doing good," the inscription reads.

The Kunyang epitaph is a portrait of the fundamental human values Zheng He most admired. It is also the first of three surviving personal statements, each of them inscribed in stone, that provide a rare glimpse into the private thoughts of a man born in the war-ravaged 14th century—but struggling to escape its martial obsessions.

MAIDEN VOYAGE

The Green Eyebrow was a renowned Song dynasty junk, named for the menacing glare painted on her bow and rebuilt in 2002 to original scale. She rolls like a duck at her mooring, fighting a stiff wind at the mouth of the Yangtze River, where Zheng He's baochuan entered the East China Sea in 1405. Zhang Yonghua, a sailing master for 38 years, peers into the morning haze from the helm, his back ramrod straight, his face a study in placid concentration.

He nods at his first officer, who motions at a windlass, and four barefoot sailors spring into action, hauling 350 feet of anchor chain aboard. Several paces aft at a second windlass, six more men begin raising sails. The sailors chant an ancient

naval dialogue, their rhythmic "Yeee-yee-yo!" answered by the officer's sharp, commanding "Ai hah!"

Within minutes the rolling vanishes and the Green Eyebrow takes flight over the waves. The first officer gives us the thumbs-up sign, then turns to Captain Zhang for his orders—just as the officers of the Ming flagship must have turned, making sail on this very sea, to Admiral Zheng He.

By the last week of 1405 the baochuan were harbored at the city of Qui Nhon in Champa, part of present-day Vietnam. After Champa the expedition proceeded to the islands of Java and Sumatra in what is now Indonesia, then west toward the most distant lands on its maiden journey, Sri Lanka and the Malabar Coast of India. Altogether, the voyage to India covered some 6,000 miles, at an estimated average speed of 50 miles a day.

From the beginning the Treasure Fleet mixed business with exploration and diplomacy, carrying more than a million tons of Chinese silk, ceramics, and copper coinage on its westward runs, to be exchanged for tropical spices, fragrant woods, precious gems, animals, textiles, and minerals. And from the beginning it sailed troubled waters. Over the course of his seven expeditions Zheng He would be drawn into countless regional conflicts. Few were more storied than his 1407 encounter in the Strait of Malacca with the infamous Cantonese pirate Chen Zuyi.

Since well before the Middle Ages, the narrow passage between Sumatra and the Malay Peninsula has been essential to international trade. In 1407 Chen Zuyi was its unrivaled scourge. Operating out of Palembang, a city on Sumatra with a large Chinese population, his heavily armed junks intercepted almost every convoy that passed, including the Ming armada.

Zheng made the opening gambit, demanding Chen's surrender, and the pirate quickly signaled agreement—while preparing for a surprise preemptive strike. But details of his plan had been provided to Zheng by a local Chinese informant, and in the fierce battle that ensued, the pirate

fleet was destroyed and 5,000 of its men killed. Chen was captured and held for public execution in Nanjing.

The informant was installed as Palembang's new ruler and incorporated into what would become a far-flung system of allies who acknowledged Ming supremacy in return for diplomatic recognition, military protection, and trading rights. By the end of the Yongle reign, the kings or ambassadors of more than 30 foreign states had paid official visits to the emperor bearing tribute. They were ferried to China in luxurious staterooms on the *baochuan*.

The most detailed record of Zheng He's triumph on the Strait of Malacca is found in *The Overall Survey of the Ocean's Shores*, published in 1451 by Ma Huan, a Chinese Muslim from Zhejiang who spoke Arabic and served as an interpreter on at least three of the voyages.

Ma is entranced by the exotic customs and bounty of the tropics, where most of the fleet's destinations lay. "How can there be such diversity in the world?" he exclaims at one point.

In Champa he and his fellow sailors dine on the succulent jackfruit, with its "morsels of yellow flesh, as big as a hen's egg and tasting like honey."

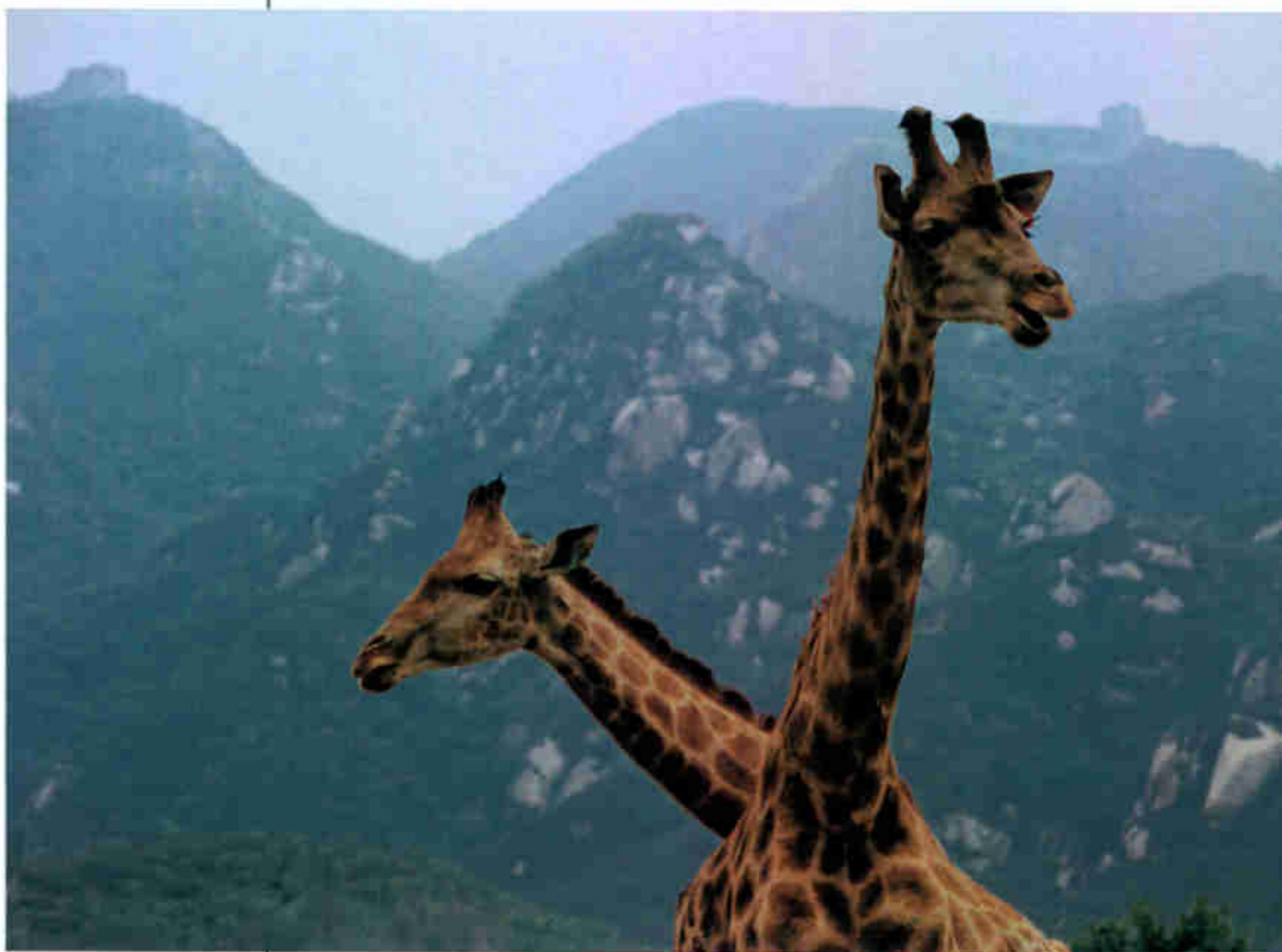
"The coconut has ten different uses," he learns in India, ranging from sweet syrup, wine, and oil to the production of rope-fiber, thatched roofs, and shell bowls.

So extensive is the array of spices, nuts, herbs, plants, and cooking styles described and cataloged by Ma, says Mark Stephen Mir, of the University of San Francisco's Ricci Institute for Chinese-Western Cultural History, "that you could probably trace Zheng He's voyages along culinary lines alone."

The Treasure Fleet crewmen are dazzled by the strange birds of Java—cockatoos, mynahs, and parrots—"all of which can imitate human speech," Ma enthuses. But he is appalled by the incessant violence of real humans on Java, where he discovers that "little boys of three years to old men of a hundred years" routinely carry knives.

"If a man touches their head with his hand, or if there is a misunderstanding about money at a sale, or a battle of words when they are crazy with drunkenness, they at once pull out these knives and stab [each other]."

Zheng's ships carry thousands of young sailors. Not surprisingly their imaginations—and shore leaves—are often aimed at the opposite sex. "If a woman is very intimate with one of our men, wine and food are provided, and they drink and sit and sleep together," Ma reports from the Kingdom of Siam, today's Thailand. Siam's men, by his account, are no less erotically inclined: At the age of 20, he writes, they insert tin or gold



CHINA *Giraffes at a zoo near the Great Wall recall the fleet's role in discovery—and diplomacy. Zheng's ships brought home at least one giraffe, a gift for the emperor.*

beads in their foreskins, which "when the man walks about, make a tinkling sound. . . . This is a most curious thing."

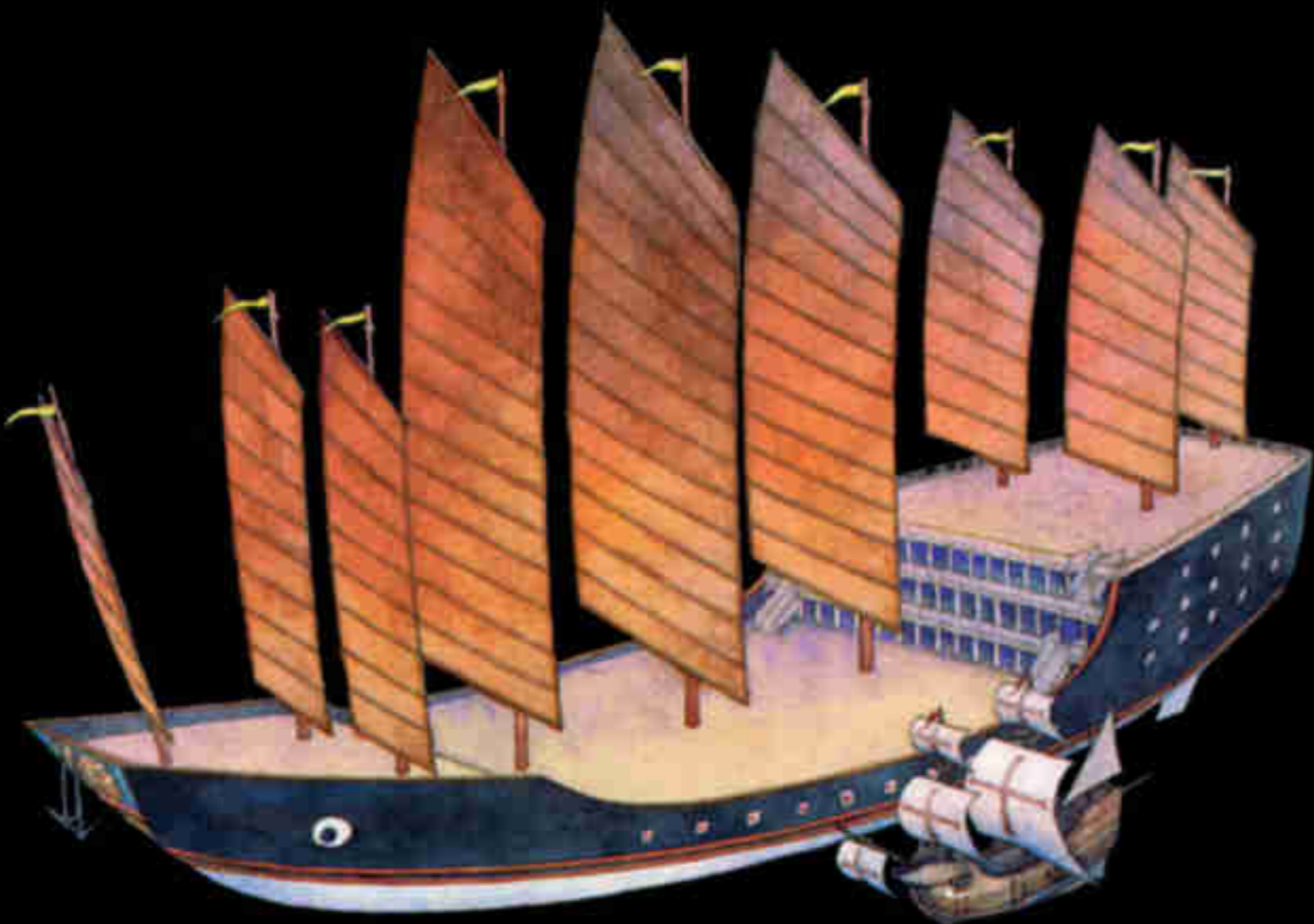
Ma pondered funeral and marriage rites, domestic and public architecture, religious beliefs, languages and dialects, trade goods and commercial practices, weights and measures, flora and fauna, science and technology, the strengths and weaknesses of governments.

The voyages were a floating encyclopedia-in-progress for Ming China—a compilation of all worth knowing between Nanjing and Africa.

Voyages of Zheng He

1405-1433

The ships of Zheng's armada were as astonishing as its reach. Some accounts claim that the great baochuan, or treasure ships, had nine masts on 400-foot-long decks. The largest wooden ships ever built, they dwarfed those of Portuguese explorer Vasco da Gama (art, below). Hundreds of smaller cargo, war, and supply ships bore tens of thousands of men who brought China to a wider world.



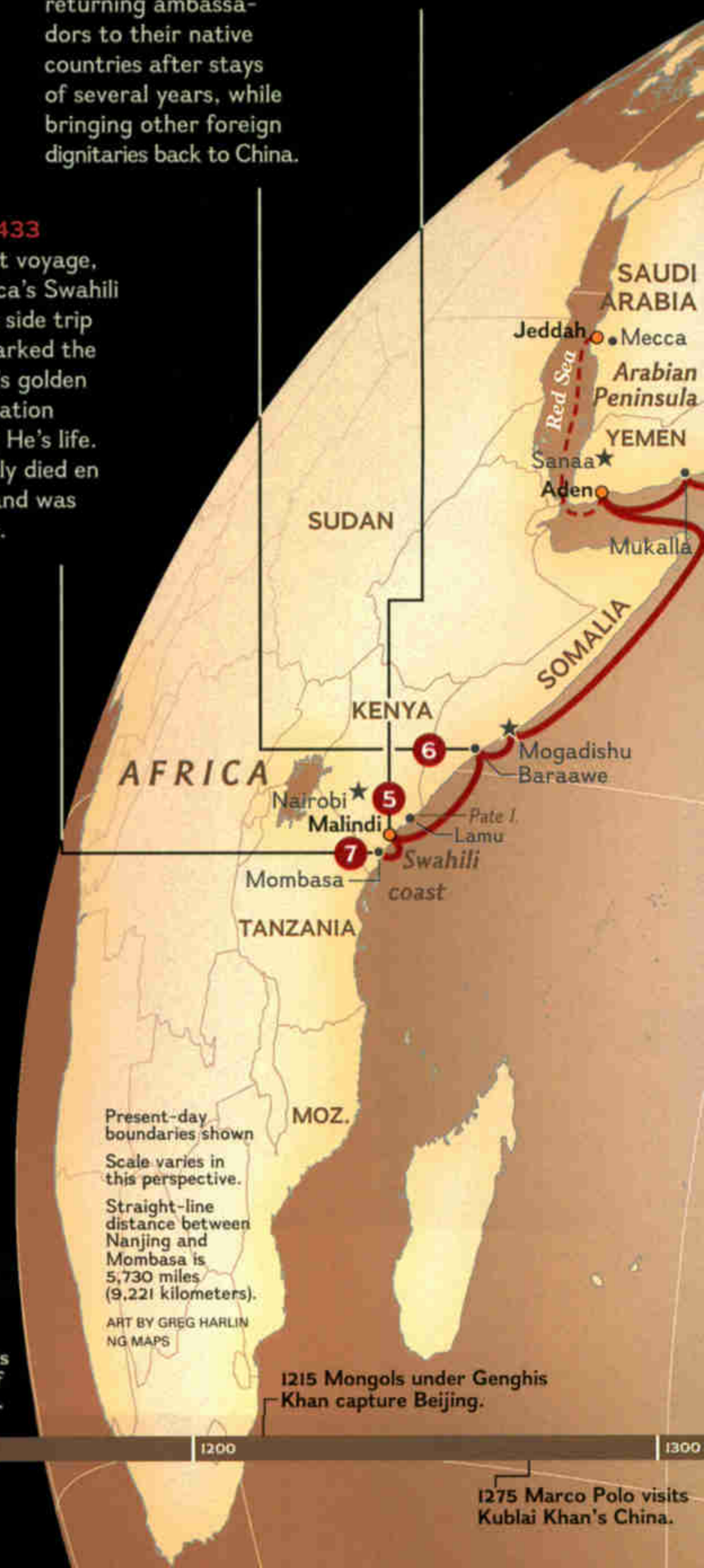
A MING TREASURE SHIP
Perhaps 400 ft (122 m) long, 170 ft (52 m) wide

VASCO DA GAMA'S SÃO GABRIEL
About 74 ft (23 m) long, 18 ft (5 m) wide

6 1421-1422
Zheng He's fleet continued the emperor's version of shuttle diplomacy, returning ambassadors to their native countries after stays of several years, while bringing other foreign dignitaries back to China.

7 1431-1433
The last voyage, to Africa's Swahili coast, with a side trip to Mecca, marked the end of China's golden age of exploration and of Zheng He's life. He presumably died en route home and was buried at sea.

5 1417-1419
Zheng's Treasure Fleet visited the Arabian Peninsula and, for the first time, Africa. In Aden the sultan presented exotic gifts such as zebras, lions, and ostriches.



A Shrinking World

ca 1000 Leif Eriksson makes landfall in Newfoundland.

1100s Chinese junks call at Persian Gulf and Red Sea ports.

1215 Mongols under Genghis Khan capture Beijing.

A.D. 1000

1100

1200

1300

ca 1050 Floating compass in use by Chinese navigators

ca 1070 Chinese develop dry docks.

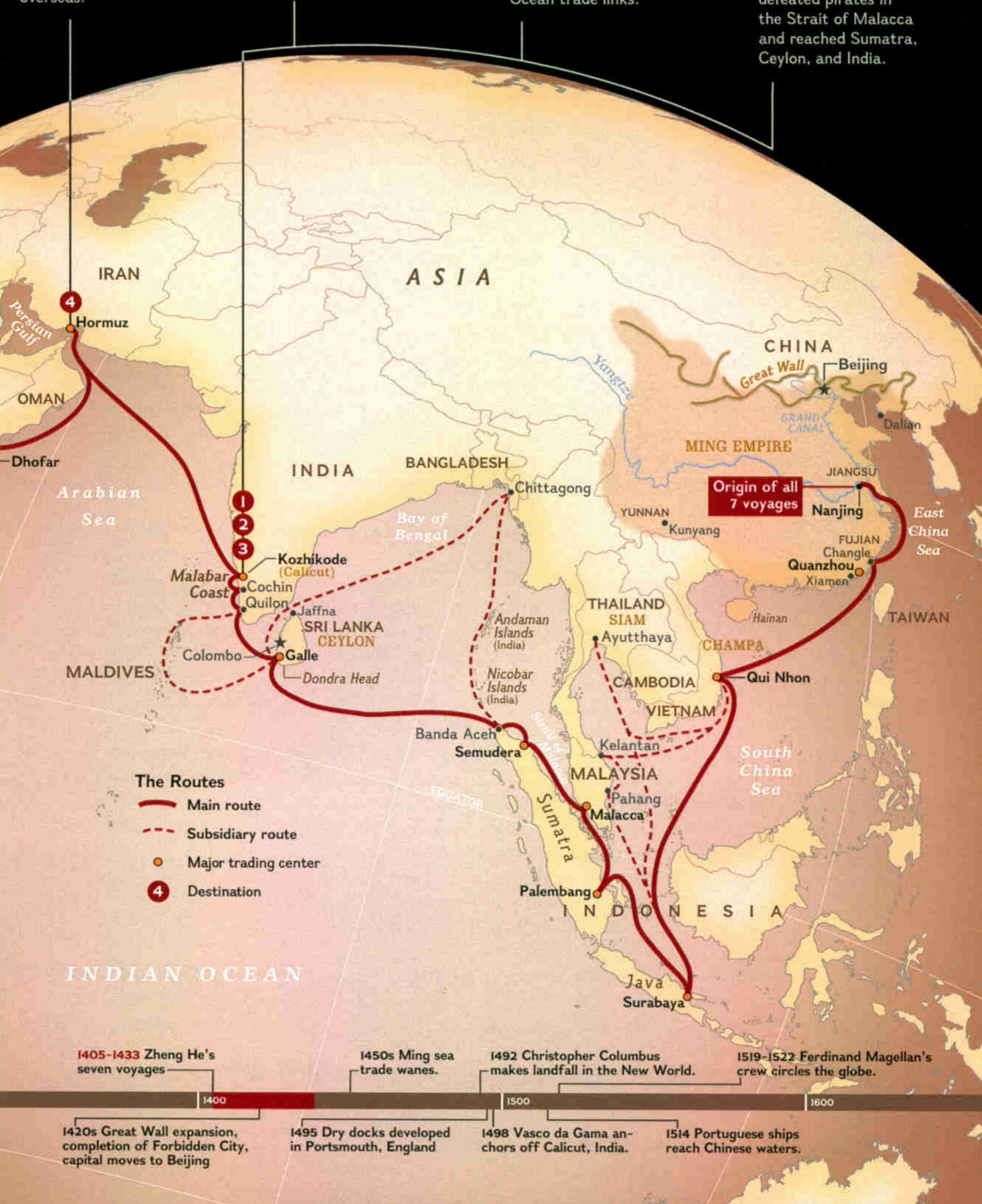
1275 Marco Polo visits Kublai Khan's China.

4 1413-1415
In this voyage's wake, the first to travel beyond India and cross the Arabian Sea, an estimated 18 states sent tribute and envoys to China, underscoring the Ming emperor's influence overseas.

3 1409-1411
Although notable for the imperial fleet's only major foreign land battle, the voyage was also marked by Muslim Zheng's offering of gifts to a Buddhist temple, one of many examples of his ecumenism.

2 1407-1409
The fleet returned foreign ambassadors from Sumatra, India, and elsewhere who had traveled to China on the first voyage. The expeditions firmly established the Ming dynasty's Indian Ocean trade links.

1 1405-1407
317 ships
27,870 men
In July the fleet left Nanjing with silks, porcelain, and spices for trade. This well-armed floating city defeated pirates in the Strait of Malacca and reached Sumatra, Ceylon, and India.



He was, according to family sources, as outsized as his ships: seven feet tall, with a waist five feet in circumference, “and a voice as loud as a huge bell.”

ORDER AND LIGHT

Chen Yanhang, an engineer in the port city of Xiamen, has studied the Ming naval scrolls for years. “Going to sea, then and now, was about science,” he says.

We are having lunch with two retired captains, Lin Jinlei and Xu Caiquan, the modern counterparts of the baochuan commanders. Captain Lin echoes engineer Chen: “My men used to pray to a little statue of Mazu, the goddess of the sea, just like they did in Zheng He’s time. But I don’t believe in gods. I believe in facts.”

Captain Xu shakes his head and tells a story: “We were 48 days into a run from New Orleans to Dalian in 1982, via Africa and the Strait of Malacca. Suddenly a north wind screamed in, and the waves heaved a giant sea turtle onto the deck.

“Some of the men wanted to carry it to the Dalian zoo. Others, especially the old-timers, said nothing at all. We locked it up, and 24 hours later the wind was so fierce that I hove the ship to, hoping we could ride out the storm. We’d heard on the radio that three ships had already gone down. That night one of the old-timers crawled over the deck and set the turtle loose. The wind fell a few hours later. Another day, and we’d have been finished.”

Captain Xu pauses, and in his eyes I see the timeless power and mystery of the sea. “I believe in science too,” he says, “but I also believe that turtle was more than a turtle.”

The deeper motives behind Zheng He’s voyages are a matter of intense scholarly debate, with rival historians citing trade, gunboat diplomacy, military defense, and even the personal insecurity of Zhu Di—who was said to fear that his nephew, the dethroned emperor, had escaped overseas. Zheng He, in this interpretation, was sent abroad to hunt Zhu’s predecessor.

Contemporary sources on the Yongle reign are exceedingly scarce. “Of the several million Ming documents once held in the central government archives in Beijing and Nanjing, all but 10,000 were destroyed in the fighting at the

end of the dynasty,” notes Endymion Wilkinson of Harvard University. By contrast, he adds, “14 million original government documents survive from the archives of the Qing dynasty,” which lasted from 1644 to 1911.

In the end no general explanation for the voyages seems more convincing than the yearning for order after a century of almost unprecedented violence—a yearning for the assurances of fact and discovery set against a backdrop of worldwide chaos.

The Mongol Empire, which once stretched from the Danube to the Sea of Japan, had been shattered into a mosaic of warring fragments. In Central Asia the merciless Tamerlane had risen to power, seizing Baghdad and Delhi, then turning east with a vast army and bent on invading China. Only his sudden death in 1405 ended the menace. Sri Vijaya and Angkor, the former superpowers of Southeast Asia, were vanishing into the jungles of Sumatra and Cambodia. Heaven itself seemed to have turned its back on humanity. Catastrophic epidemics and famine in the 14th century had killed an estimated one in three Chinese—35 million people.

Zhu Di’s father chose to call his new dynasty Ming, “brightness,” in explicit contrast with the dark chaos of his times. Brightness lay in order—and in the early 15th century, order depended on a phenomenally energetic and expansive China. The imperial mandate, Treasure Fleet sailor Fei Xin wrote in his diary, was to bring order “to the four quarters [of the Earth] . . . as far as ships and carts would go and power of men would reach.”

It was a daunting task that, on his third voyage, would lead Zheng He into a savage conflict thousands of miles from China.

Along the 22-mile road from Elephant Pass to Jaffna, on the northern tip of Sri Lanka, not a single building remained whole in the summer of 2004. Over the past decade many had been reduced to nothing more than knee-high mounds of rubble. Last August I walked through

the ruins with two friends, Rukshan and Viji Jayewardene. Our tour came to a wordless end in a stain-splattered courtyard. The stains had dried dark-brown in the tropical heat, but it was obvious that they were recently blood-red, and that a number of people had been shoved against the courtyard wall and executed here.

In 1411 Zheng He had intervened in an earlier war on the island, pitting Hindu Tamils from the north against two mutually hostile Sinhalese Buddhist realms in the center and south. Zheng was forced to act when one of the Buddhist rulers, a rebel chieftain, attacked a Ming shore party. In a stroke of military genius, the main body of Sri Lankan troops was lured into a fruitless assault on the fleet, leaving their capital open to easy conquest.

The episode marked the only significant overseas land battle ever fought by a Chinese imperial army. It so strengthened the legitimate Sinhalese king, Parakramabahu VI, that he went on to defeat the Tamils and govern Sri Lanka for 55 years, before the kingdom collapsed into warring divisions once more.

Six centuries later those divisions remain ferocious. In their current guise, they pit the lethal guerrilla force known as the Liberation Tigers of Tamil Eelam against the Sinhalese-dominated central government in Colombo, the nation's modern capital.

A fragile truce was in effect when I went to Jaffna with Rukshan and Viji, and held through the aftermath of December's tsunami, which killed tens of thousands in Sri Lanka and forced government troops and Tiger insurgents to cooperate in relief efforts. But the long-term picture remains ominous.

Rukshan, a quiet and introspective archaeologist and wildlife photographer, was obliged to keep a low profile because his grandfather, Junius Jayewardene, had been president when the Tamil-Sinhalese conflict reopened in the early 1980s. Now it was dangerous simply to be a Jayewardene in northern Sri Lanka.

Jaffna was a stark reminder of irrational hatred's demoralizing tenacity. Zheng He believed he had put the same crisis to rest 600 years ago—and carved its resolution in stone.

In 1911 a British engineer out for a stroll near the harbor city of Galle chanced upon a strange granite slab with inscriptions in Chinese, Tamil, and Persian. It proved to be a commemorative stela raised by Zheng in 1410 at Dondra Head.

The stela's three inscriptions were addressed, respectively, to Buddha, Siva, and Allah, offering thanks for their compassion and moral virtue, and seeking their protective blessing for the voyages' aims. The chief Buddhist, Hindu, and



I N D O N E S I A *On a volcano on Java, laborers haul sulfur, which Zheng's fleet collected for use in medicines, alchemy, and gunpowder, a Chinese invention. Gathering commodities across half the globe, the fleet imported industrial metals, sandalwood, ivory, and exotic spices such as pepper.*

Muslim shrines of Sri Lanka, the stela recorded, were to be presented with equal offerings of gold, silver, silk, and other precious gifts.

Elsewhere in Asia this is the epoch when entire cities were put to the sword in the name of Buddha, Siva, or Allah. It is the epoch of the Inquisition in Europe, when thousands of Muslims and Jews were burned at the stake. In the context of his century's (Continued on page 46)





MALAYSIA In a pointed melding of cultures, ethnic Chinese in Malacca thank the gods for favors with a self-mortification rite during a Hindu festival. A Chinese settlement expanded here after Malacca became the home port for Zheng's fleet in Southeast Asia. Seeking fortune abroad, thousands of Chinese flocked to ports along Zheng's route, seeding a diaspora that still thrives today.



SRI LANKA *Muslims, Hindus, Buddhists, and Christians revere Adam's Peak, which bears an impression said to be the footprint of Adam, Siva, or Buddha. A devout Muslim, Zheng had an encyclopedic interest in other cultures that bred tolerance. He wrote of the "transforming power of virtue," and of the need to "treat distant people with kindness."*



“We have set eyes on barbarian regions far away hidden in a blue transparency of light vapors, while our sails loftily unfurled like clouds day and night.”

religious fanaticism, Zheng He's Dondra stela was an ecumenical manifesto far ahead of its time—indeed, ahead of our own fanatic times—a plea for tolerance, articulated in three languages.

THE WORLD OF EXCHANGE

Ma Huan sits on deck with younger interpreters, sharing what he knows of the ports that lie ahead, of the stories they'll hear, and of the strange new words they must learn. In the language of India, he explains, a prince is called a raja. In the Chinese characters of his diary he will express this as lazha. A king, he adds, is a mahalazha. Ma is the first linguist to transcribe hundreds of foreign words into Chinese, including gaoli (the cowry shell), jiashi (cash), and sakala, the textile Shakespeare would know as sackcloth.

He will also be among the first Chinese writers to tell the story of a holy man who leads his people on a long journey, then appoints his brother to watch over them while he himself goes off to speak with God. In his absence, Ma relates, the brother allows their people to worship “a golden ox.” In Chinese Ma refers to the holy man as Mouxie, a close approximation of the Arabic name for Moses.

The young interpreters listen. Between Ma Huan's lessons and stories, they can hear the sailor who walks the deck from fore to aft, following a float in the sea that measures speed. If the sailor walks 150 feet in 50 seconds, the ship is making two knots on its voyage west, toward the land of the mahalazha.

If tortured Sri Lanka symbolized one pole of Zheng He's personal itinerary, the Malabar Coast of India—the main destination of every one of the Treasure Fleet's seven voyages—was its opposite extreme. Malabar, with its cosmopolitan trading cities of Calicut (now Kozhikode) and Cochin was, in effect, Zheng's second home for most of his years overseas. “The great country of the Western Ocean is precisely this country,” Ma Huan flatly declared.

Nisar Ahmed Lone put it more strongly: “This is God's true country,” he told me, “a country

where everyone is a brother.” He is a cloth merchant who moved his family to Cochin 13 years ago from their native Kashmir.

The Lones are Muslim, which could be a death warrant in some parts of Asia, just as being Hindu or Christian is in others. In Cochin, Lone said, “religion is a private matter, a private choice.” In fact, he told me, the city's Muslims often send their children to the local Catholic schools—according to Malabar tradition, Christianity has been present here since the first century A.D.—simply because it is thought that their teachers are excellent.

Malabar's tolerance must have been breathtaking for Zheng He, a rare living example of the ecumenical dream he'd articulated at Dondra Head. A Calicut Hindu maharaja, Ma Huan wrote, “made a sworn compact with the Muslim people, saying: ‘You do not eat the pig. I do not eat the ox. We will respectively observe these taboos.’” The compact, Ma noted, “has been honored right down to the present day.”

I read Ma Huan's words to Vipin Vasudevan in the Cochin offices of the India Pepper and Spice Trade Association, on the very street where Zheng He's commercial agents had once talked business. Vasudevan, then the association's marketing executive, was managing the annual sale of 66,000 tons of Malabar pepper. A smile of recognition slowly lit his face as he listened to a passage from Ma about a 15th-century negotiating session in Malabar. Supervised by the Cochin maharaja's personal representative, it brought together local brokers, accountants, and prospective buyers. Goods and costs were discussed, an agreement drafted. Then, Ma wrote, all the parties joined hands, declaring “whether the price be dear or cheap, we will never repudiate it or change it.”

It was, said Vasudevan, “so close to how pepper trading works now, that I could have written it myself.” The Spice Trade Association had replaced the king's representative at the negotiating table, but the general process had barely changed. “Everyone involved is legally

bound by the agreement,” Vasudevan said, then added: “We are all morally bound by it as well.”

Ma had written one of history’s first descriptions of a futures market, the means by which Malabar pepper and most other world commodities are sold today. A market that can function only if Vasudevan’s “moral bond” holds. A model of exchange in a world ever wracked by conflict.

It took me three days’ travel out of Nairobi, by air, land, and sea, to reach Pate Island. I had been warned by Kenyan officials that roads into the area were dangerous, beset by marauding gunmen from wars in Somalia and Sudan.

Pate lies in Kenya’s Lamu archipelago, just south of the Somali border. En route to its principal African destination, Malindi, the Treasure Fleet almost certainly anchored there for water and provisions.

In the 14th century Malindi and Pate were among the richest of the Swahili kingdoms, a grand civilization of merchant princes whose realm extended as far south as Mozambique. Reminders of that brilliant past are everywhere in the Lamu archipelago. Traditional wooden trading dhows are still built in Lamu, the islands’ capital on Lamu Island, and the doors on its aging mansions are encircled with shards of pottery that wash up on the beaches.

Ghazzal Harith Swaleh, the learned administrative officer of Lamu’s Swahili history museum, is convinced that the pottery is from Zheng He’s fleet—a ship or two caught in a storm and foundered on the shoals. Local legend has it that shipwrecked Ming sailors swam to Pate, he told me, “where they married local women.” Their descendants are said to have “Chinese eyes” and “Chinese-sounding” tribal names such as Famao and Wei.

I had arranged to sail to Pate from Lamu, wading ashore in a deserted lagoon. The landing place was called Old Shanga, explained my guide. “You know, like ‘Shanghai.’ That’s what our Chinese ancestors named it, maybe after

their hometown.” The guide didn’t look Chinese to me, nor did any of his fellow villagers in New Shanga, a collection of mud-walled huts nearby. The trip seemed to have accomplished nothing—until we reached a small clearing, deep in the jungle, where the guide pointed to a series of coral-stone structures draped in vines. “Our ancestors’ graves,” he said.

These burial places, with their half-moon domes and terraced entries, were virtually identical to the classic Ming tombs that dot hillsides above Chinese ports from which shipwrecked Treasure Fleet sailors might have hailed.

A strange melancholy seemed to hang over



I N D I A *Masters of kalaripayattu perform the ancient martial art in Calicut, where Zheng’s crewmen may have seen similar displays. Dispersing Asian arts and ferrying foreign ambassadors, Zheng was a potent agent of cultural exchange.*

the clearing, and I was glad to begin the long trek back to the lagoon.

THE LAST DAYS OF ZHENG HE

As the Treasure Fleet assembles in the autumn of 1431 at the Fujian harbor of Changle, Zheng He oversees the completion of another engraved pillar. Its inscription is a self-conscious statement for posterity. It is as though Zheng knows what lies ahead: history stands at a crossroads, and his own role in it is about to end. (Continued on page 52)





YEMEN Gypsum tracery gleams on buildings around the ancient suq, or marketplace, of Sanaa, a bustling trade center in the 15th century. Caravans carried merchants and dignitaries—along with such trade goods as frankincense and myrrh—through Sanaa to Zheng's ships at the port of Aden.



KENYA A dhow's deck and lateen sail frame Lamu Island off Africa's Swahili coast, thought to be the fleet's westernmost destination. On nearby Pate Island, many people hold to the traditional belief that they are descendants of shipwrecked Chinese sailors, perhaps from Zheng's fleet, who married local women.



CHINA *A colossal block of granite remains from Emperor Zhu Di's attempt to create a stela honoring his father. That same boundless ambition launched the Treasure Fleet, which was grounded after the emperor's death. Now China is again engaging the world, says scholar Roderich Ptak: "Zheng is a symbol of that opening."*

"[We] have recorded the years and months of the voyages to the barbarian countries," the admiral declares, "in order to leave [the memory] forever."

Zheng goes on to list the major landfalls in the previous six voyages, "altogether more than thirty countries large and small." He writes of his efforts "to manifest the transforming power of virtue and to treat distant people with kindness." He dreams, still, of a new world.

In the Chinese courtly tradition, the great admiral graces the pillar's inscription with a poetic flourish: "We have traversed more than one hundred thousand li [about 40,000 miles] of immense water spaces and have beheld in the ocean huge waves like mountains rising sky-high, and we have set eyes on barbarian regions far away hidden in a blue transparency of light vapors, while our sails loftily unfurled like clouds day and night."

When the Treasure Fleet returned to China at the end of its sixth voyage in 1422, its admiral and many of his crewmen had been abroad almost constantly for nearly two decades. They must have felt lost in their own homeland.

The Ming building boom, ignited during their first voyage, had radically altered China's cities and towns. Nanjing was no longer its capital; Zhu Di, the megalomaniac emperor who had sent the men overseas, now lived in Beijing. He was in his last months of life, about to be succeeded by his son Zhu Gaozhi. The younger Zhu died after just nine months in power. But under the influence of courtiers who opposed the costly voyages, one of his first edicts was to halt all overseas expeditions. Zhu Di's grandson Zhu Zhanji continued the ban.

The policy reversal "changed history, stopped short what might have been a very different future for Asia and the world," says Liu Yingsheng of Nanjing University, a leading Zheng He scholar. The void left by China's withdrawal from foreign engagement, he points out, was filled within the next few decades by European imperialism—and Zheng's sophisticated

combination of peacekeeping, trade, and diplomacy yielded to crude military conquest.

But policy calculations in any epoch are subject to changing conditions. In the late 1420s Ming China came under pressure, by land from a new wave of Mongol invasions, by sea from Japanese pirates, and across its far-flung tributary empire from local warlords. Zhu Zhanji began to reconsider his policy on naval expeditions—though without the sense of unblinking commitment that had characterized his grandfather. Amid rancorous debate in the court, a halfhearted decision was made to reactivate the Treasure Fleet.

It would not affect the long-term balance sheet of Ming affairs; by the end of the 1430s the advocates of isolationism in the imperial court had won a decisive victory. But before that struggle ended, the great ships would sail again, on their seventh and final voyage.

Almost every destination on this final expedition would be familiar. It is difficult not to conclude that the most notable exception had been chosen by the admiral himself: Mecca.

In the 15th century Islam framed the Western Ocean. All of the Treasure Fleet's routes had been charted, long before, by Arab and Persian captains. Every one of the fleet's destinations on the Indian Ocean and Persian Gulf had a significant Muslim community.

Islam had also been the starting point of Zheng He's immense journey. His surname, before Zhu Di changed it on an imperial whim, was Ma—the Chinese transcription of Muhammad.

Zheng's father, Ma Haji, had made the hajj, the pilgrimage to Mecca, earning his honorific title. As an admiral of the Ming Empire, Zheng himself could not bow before the symbolic throne of a foreign king. But he could send the man who often seemed his alter ego—his fellow "Muhammad," Ma Huan.



While Zheng waited in Calicut in 1432, a special mission was dispatched to the Arabian Peninsula. Three months later it arrived at what Ma Huan called the Country of the Heavenly Square. The square was the Kaaba, the shrine in Mecca that is the fulcrum of the Muslim universe. What Ma described, the account he brought back to Zheng He, is essentially what is seen during the hajj in Mecca today: “Each year on the tenth day of the twelfth moon, foreign Muslims . . . come to worship.” “The men wear long garments, the women all wear a covering over their heads and you cannot see their faces.” Some pilgrims, he noted, had made journeys lasting up to a year, from every corner of the known world.

In their solemn turns around the Kaaba, they embodied a central quality of Islam—the celebration of humble, egalitarian virtue. They

brought the story of Zheng He, who had recognized that virtue in his father, full circle.

Some Zheng biographers contend that he returned to China with the fleet, dying two years later in Nanjing. But the tomb in his name that stands on a suburban hillside outside the old Ming capital appears to be empty. It is more likely that the great admiral died on the return voyage and was buried at sea off the Malabar Coast.

If so, he found in death what he had sought throughout his extraordinary life: not a warrior’s violent end on a battlefield, but a visionary’s peace in “a blue transparency of light vapors.” □

SAIL THE SEAS with Zheng He’s armada, then join our forum: Centuries after the admiral landed in Sri Lanka, conflict persists between Hindu Tamils and Sinhalese Buddhists. Why? Go to nationalgeographic.com/magazine/0507.



NATIONAL
GEOGRAPHIC
RESEARCH AND
EXPLORATION

FIELD DISPATCH AUSTRALIA

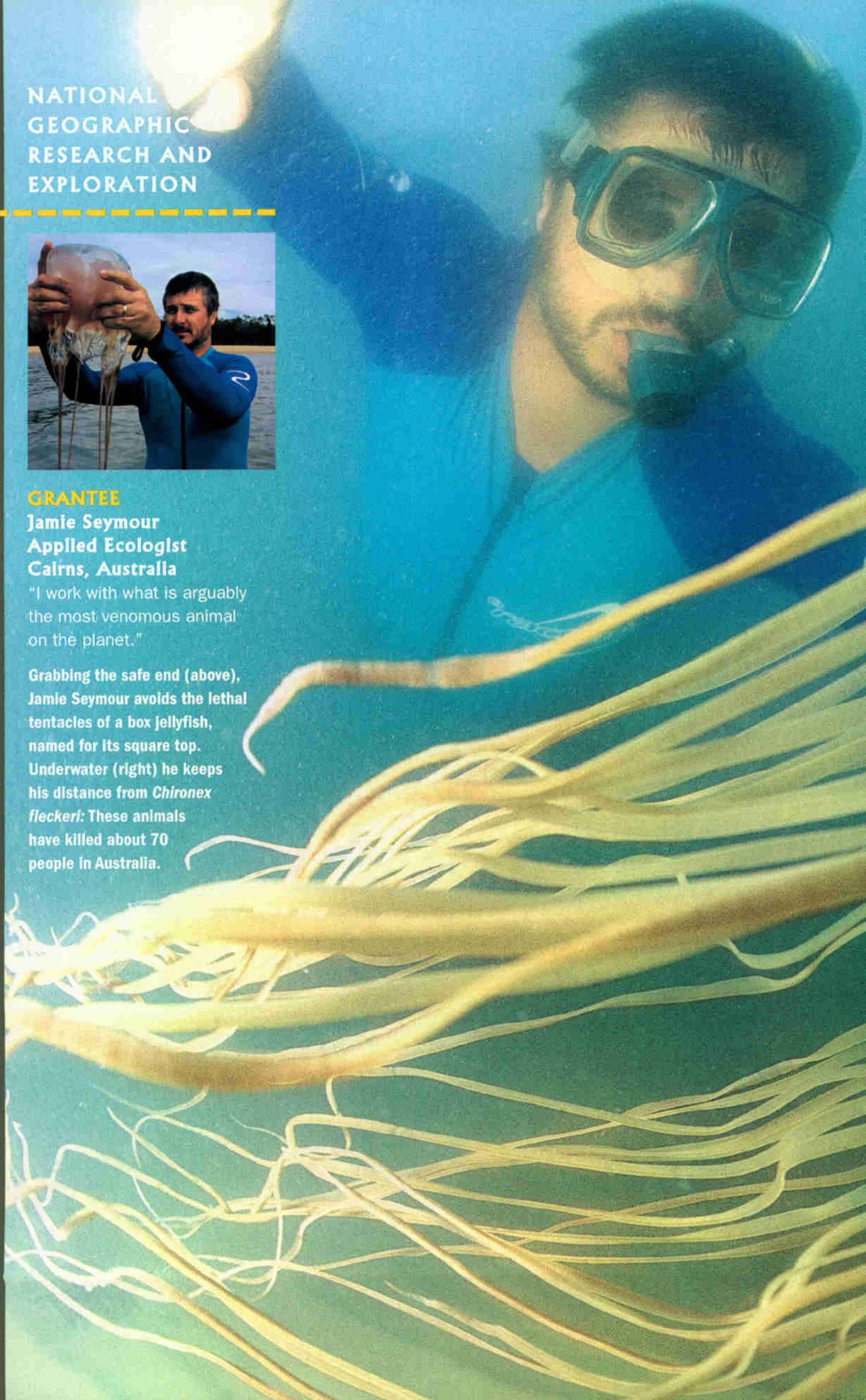


GRANTEE

Jamie Seymour
Applied Ecologist
Cairns, Australia

"I work with what is arguably the most venomous animal on the planet."

Grabbing the safe end (above), Jamie Seymour avoids the lethal tentacles of a box jellyfish, named for its square top. Underwater (right) he keeps his distance from *Chironex fleckeri*: These animals have killed about 70 people in Australia.



On the trail of box jellyfish,
a scientist helps protect
humans from deadly

Stingers



By John L. Eliot

NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by Paul A. Sutherland

Two years ago a seven-year-old boy named Jared Crook was swimming at Mission Beach in Queensland, Australia. Suddenly he screamed. His grandfather pulled him from the water, but the writhing boy soon collapsed. Within an hour he was dead of cardiac arrest—the most recent person known to have died from the venom of a box jellyfish.

Called marine stingers by Australians, these killers have captivated Jamie Seymour, an ecologist at James Cook

University in Cairns. His interest goes beyond academics: It's a matter of life and death.

To help protect the public from box jellies, Seymour studies their movements, using sonic tags to track them. But how do you attach a tag to a ball of slime? Seymour resorts to nontoxic superglue. He uses tiny ultrasonic transmitters half an inch wide, which he glues to the jellies' bells—making him the first scientist to tag jellyfish.

The solution is imperfect: Only seven attempts have

succeeded since Seymour began the work in 1999, and the tags stayed on for less than two days. Undaunted, he's working on a method to attach the tags inside the jellies' bells, where they'll be less likely to fall off.

Of the 28 or so species of box jellies, Seymour tags the largest, *Chironex fleckeri*. It can reach the size of a basketball, trailing up to 60 tentacles—each as long as 15 feet—with a total of some five billion stinging cells.

Box jellies don't deliberately

“My hands and feet were wrapped in tentacles.”

JAMIE SEYMOUR

In a hot spot for box jellyfish at Mission Beach in north Queensland, Jamie Seymour and colleague Teresa Carrette (opposite) hunt for individuals to tag. Some scientists had believed that box jellies were passive drifters, waiting for prey to bump into them. Instead, Seymour says, “they're Olympic swimmers” that move fast to actively ensnare food like mullet (top right). Tentacles draw the fish into the bell, where the stomach begins digestion (right). The tentacles then absorb the liquefied nutrients.





hunt humans, but a random brush can lead to death within minutes. Survivors bear purple ropelike scars for life, as does Seymour himself. One night he encountered a large box jelly near a pier. “Before I knew it, my hands and feet were wrapped in tentacles. I came out and couldn’t walk straight. Tears were streaming down my face.” His Lycra suit helped save him—along with a quick dousing in vinegar. Because vinegar stops *Chironex* from firing venom, Australian life-guards keep it on hand. (Sadly, it didn’t save Jared Crook.)

The best way to prevent contact is to understand where box jellies go, when, and why. Unlike most jellyfish, which are essentially blind drifters, *Chironex fleckeri* has 24 eyes and can swim in bursts of five feet a second, giving it sight and speed to hunt fish. Another oddity: Several box jellies Seymour tracked were lively during the day then lay still on the

seafloor by night, behavior unknown in other jellyfish.

Seymour’s colleague Teresa Carrette discovered that box jellies get more lethal with age. Juveniles, which hunt shrimp, have venom in only 5 percent of their stinging cells; adults have it in 50 percent of theirs, enabling them to hunt larger prey.

Fatalities from box jellies are in decline, thanks to public awareness. Many beaches now use “stinger nets” to keep them out of swimming areas. Seymour has helped by creating a computer model to predict the end of each box jellyfish season, which runs from about November to June. “City councils now use it to determine when it’s safe to remove their stinger nets,” he says. “That’s the most gratifying part of our research.” □

LETHAL SWIMMERS Learn more about box jellyfish through a bibliography and web links at nationalgeographic.com/magazine/0507.



THE PROJECT

PRIMARY RANGE OF *CHIRONEX FLECKERI*:

Coastal waters of northern Australia

TAGGED SINCE 1999:

Seven, all in Australia

RESEARCH GOALS: Deployment of micro-transmitters on jellyfish, and studying their venom

BIGGEST REWARD: Designing a computer model to predict annual jellyfish movements



Making a
splash on
MARS

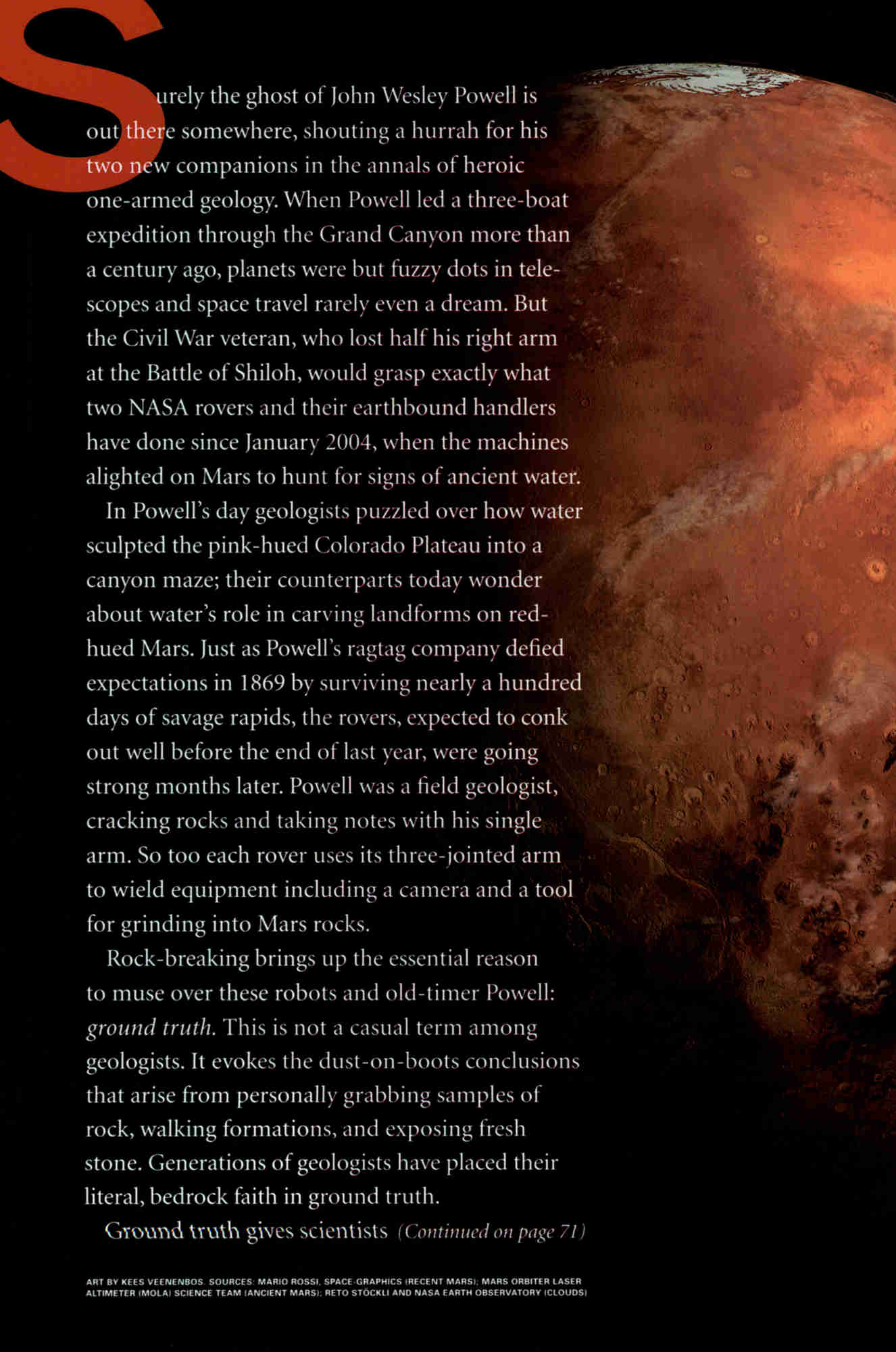
Two robot explorers.
More than a year
tracking signs of
ancient water.
And no escaping
the question:
**Was the red
planet once home
to life?**

by Charles W. Petit



Self-Portrait

Casting a long shadow into Endurance crater, NASA's rover Opportunity—and its twin, Spirit, on the other side of the planet—were expected to lose power and die last year. Instead they kept piling up the evidence for ancient Martian water.

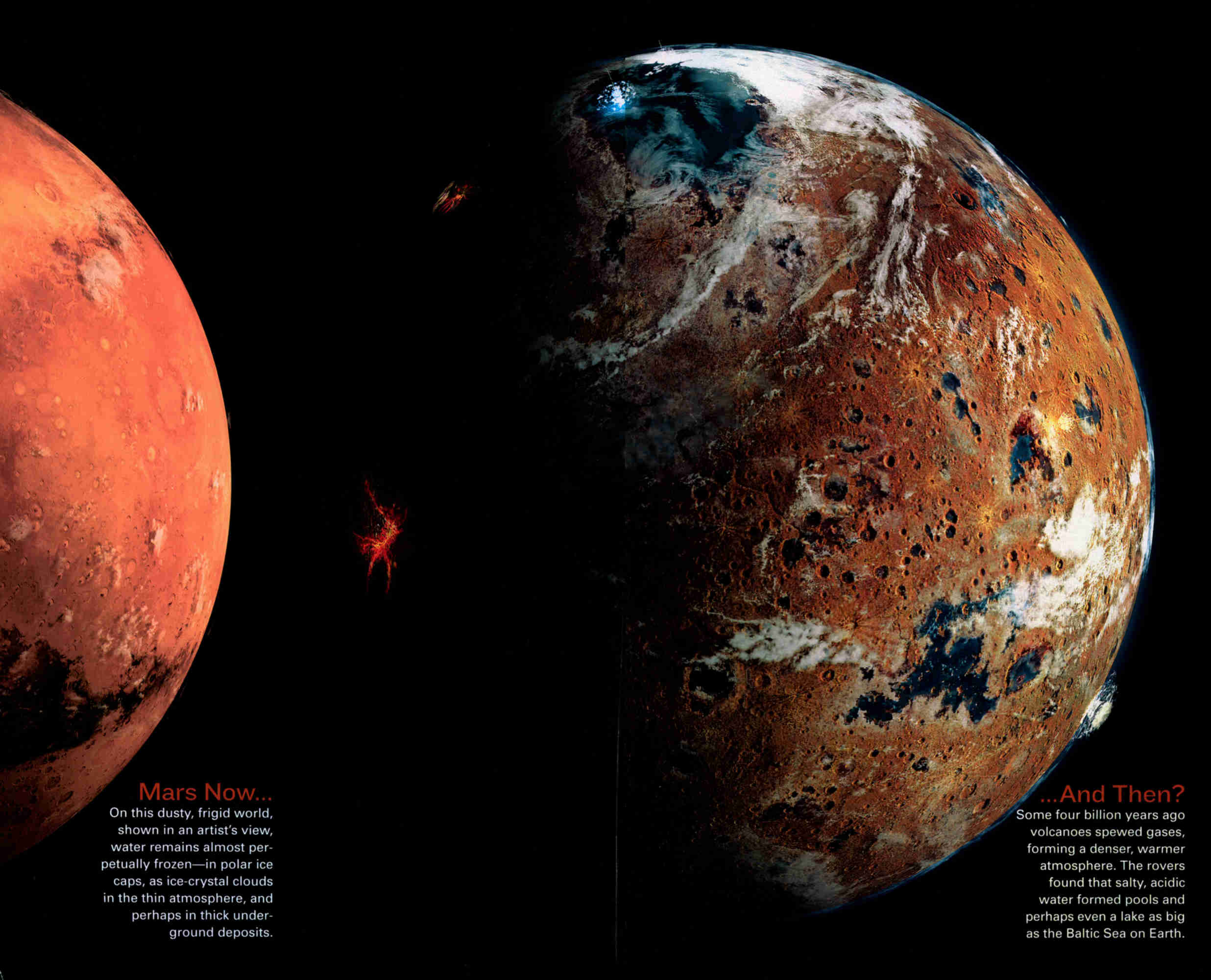


Surely the ghost of John Wesley Powell is out there somewhere, shouting a hurrah for his two new companions in the annals of heroic one-armed geology. When Powell led a three-boat expedition through the Grand Canyon more than a century ago, planets were but fuzzy dots in telescopes and space travel rarely even a dream. But the Civil War veteran, who lost half his right arm at the Battle of Shiloh, would grasp exactly what two NASA rovers and their earthbound handlers have done since January 2004, when the machines alighted on Mars to hunt for signs of ancient water.

In Powell's day geologists puzzled over how water sculpted the pink-hued Colorado Plateau into a canyon maze; their counterparts today wonder about water's role in carving landforms on red-hued Mars. Just as Powell's ragtag company defied expectations in 1869 by surviving nearly a hundred days of savage rapids, the rovers, expected to conk out well before the end of last year, were going strong months later. Powell was a field geologist, cracking rocks and taking notes with his single arm. So too each rover uses its three-jointed arm to wield equipment including a camera and a tool for grinding into Mars rocks.

Rock-breaking brings up the essential reason to muse over these robots and old-timer Powell: *ground truth*. This is not a casual term among geologists. It evokes the dust-on-boots conclusions that arise from personally grabbing samples of rock, walking formations, and exposing fresh stone. Generations of geologists have placed their literal, bedrock faith in ground truth.

Ground truth gives scientists *(Continued on page 71)*

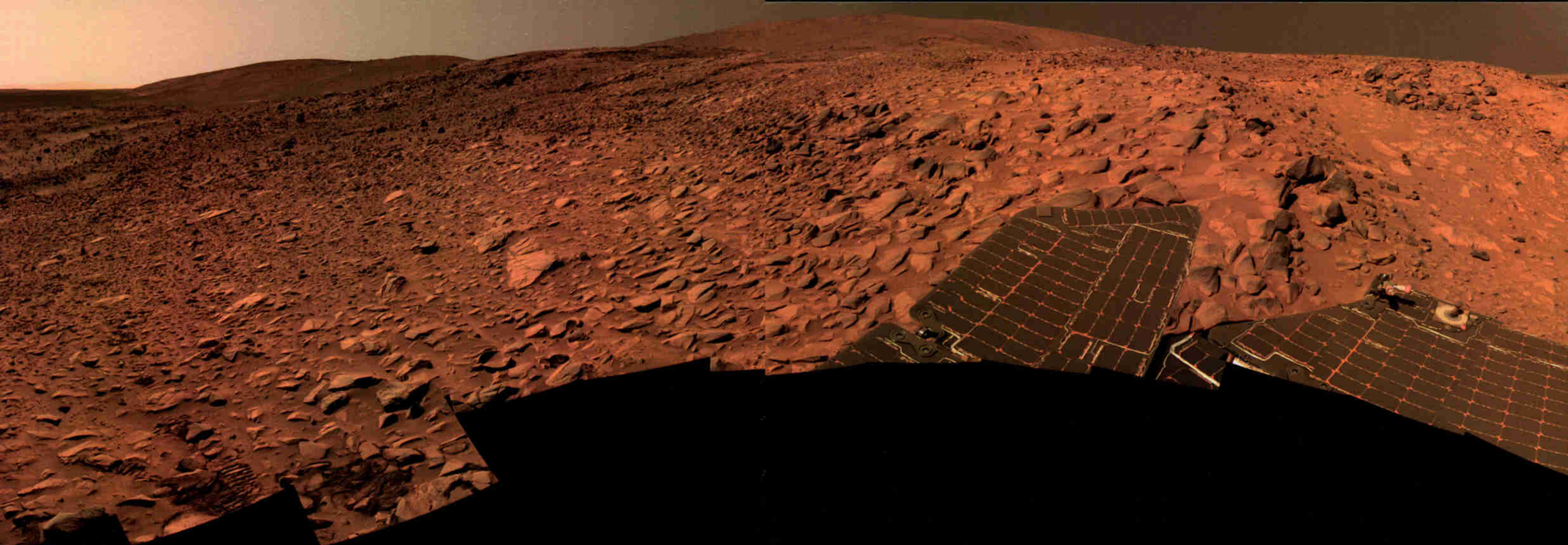


Mars Now...

On this dusty, frigid world, shown in an artist's view, water remains almost perpetually frozen—in polar ice caps, as ice-crystal clouds in the thin atmosphere, and perhaps in thick underground deposits.

...And Then?

Some four billion years ago volcanoes spewed gases, forming a denser, warmer atmosphere. The rovers found that salty, acidic water formed pools and perhaps even a lake as big as the Baltic Sea on Earth.

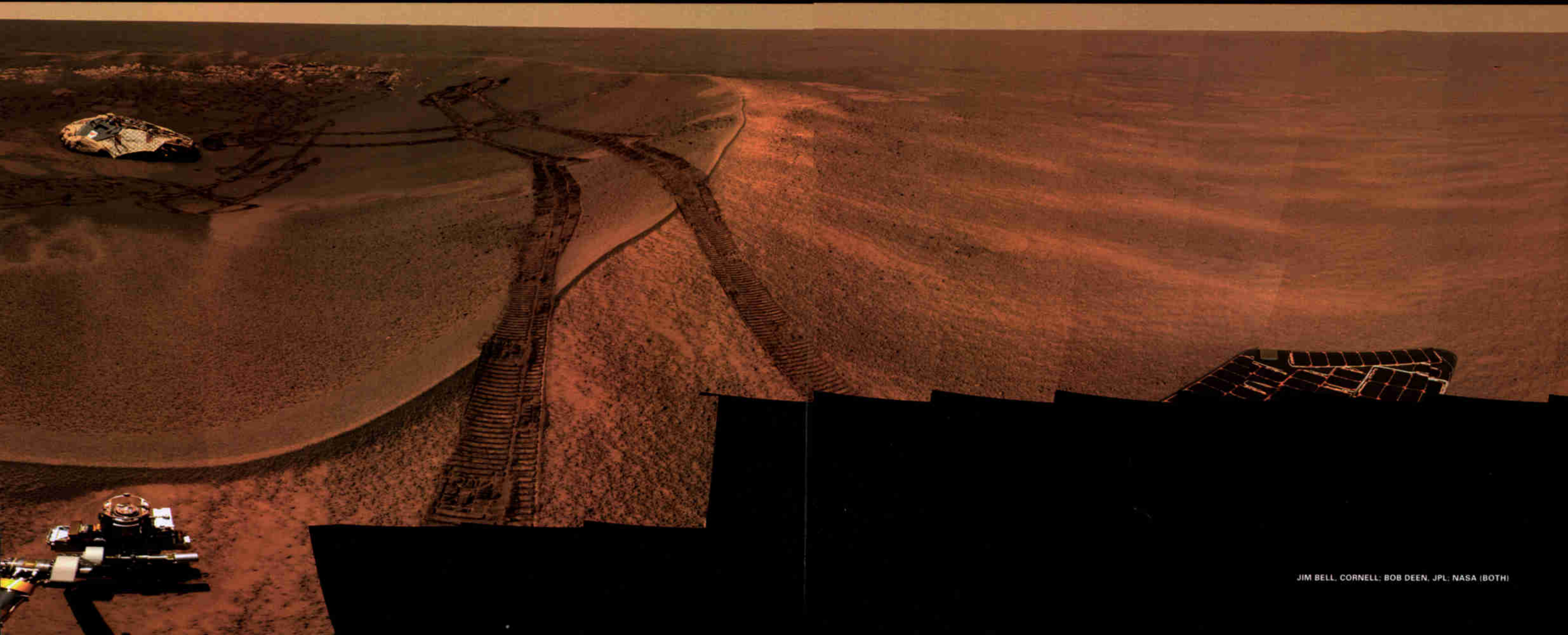
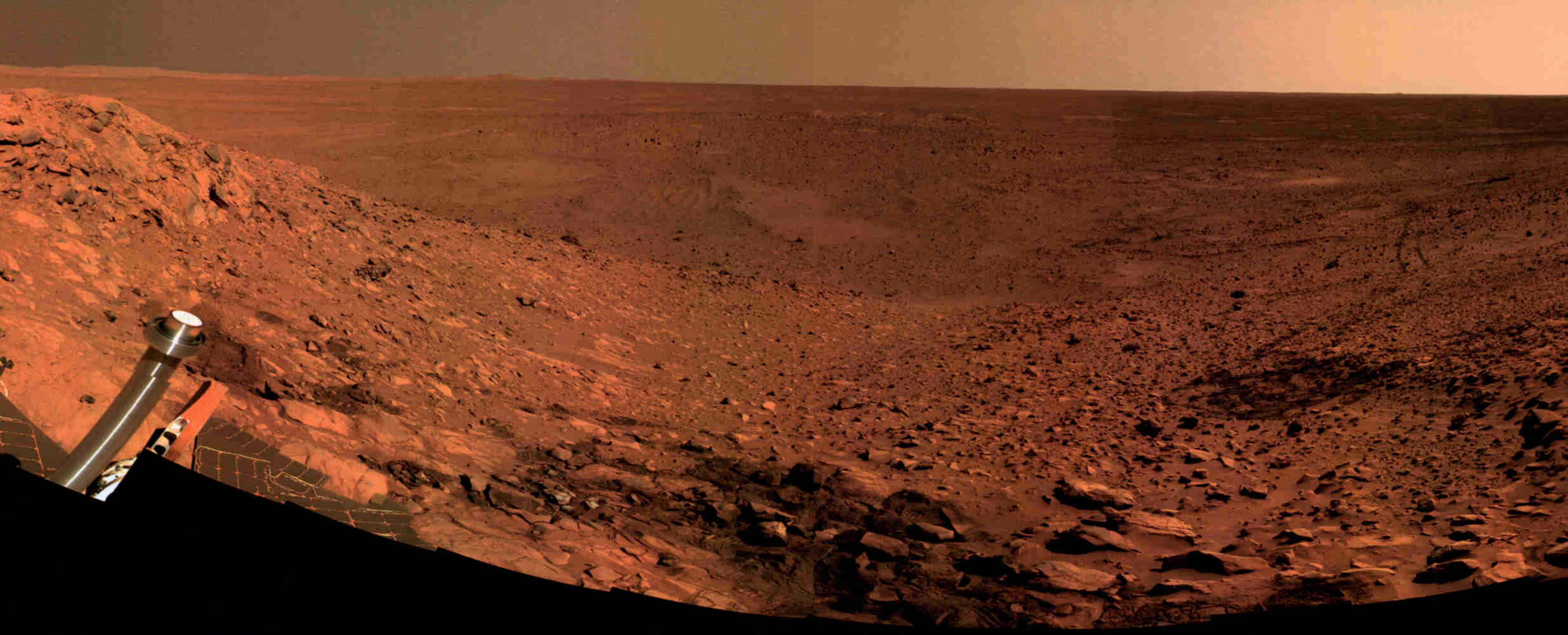


Spirit Digitally spliced together, about 450 of the rover's images provide this view of the rocky Columbia Hills, spanning almost 360 degrees. Beyond the hills, the plains of Gusev crater can be seen stretching to a horizon 50 miles away.

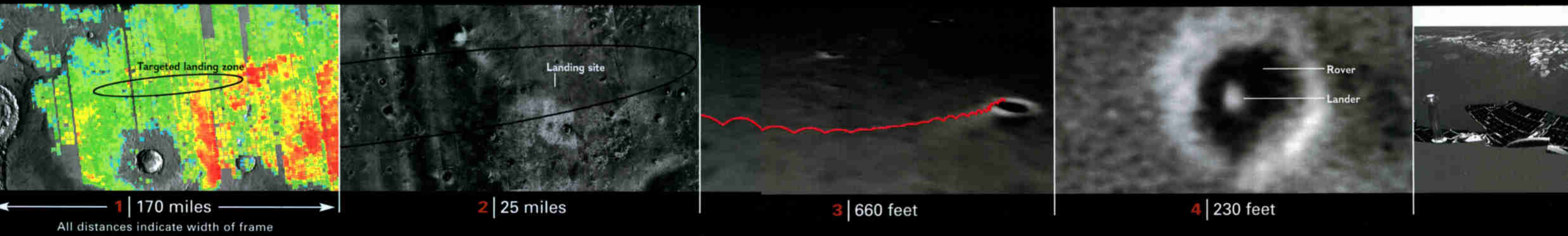


Opportunity This 550-image panorama of the Meridiani plain shows 65-foot-wide Eagle crater, where the spacecraft came to rest. Visible in the crater are the lander and the pale rocks that yielded the first solid evidence for Martian water.

► Manipulate 360° panoramas of the views above at nationalgeographic.com/magazine/0507.



From Orbit...



Zooming in on Mars

A series of images (above) shows how hints of ancient water glimpsed from orbit turned into hard evidence of a watery Martian past when Opportunity landed and took a close look at the rocks.

1 Infrared data from orbit show a region of gray crystalline hematite, a mineral that signals where water might have been present on Mars (red indicates highest concentration). Opportunity's targeted landing zone was about 50 miles long.

2 A closer look at the landing zone reveals the small crater where Opportunity came to rest.

3 A computer-generated red line on a mosaic of images from Opportunity's descent camera traces the lander's bouncing path into 65-foot-wide Eagle crater.

4 Two weeks after the landing, an image from orbit shows that the rover had moved off its lander in Eagle crater.

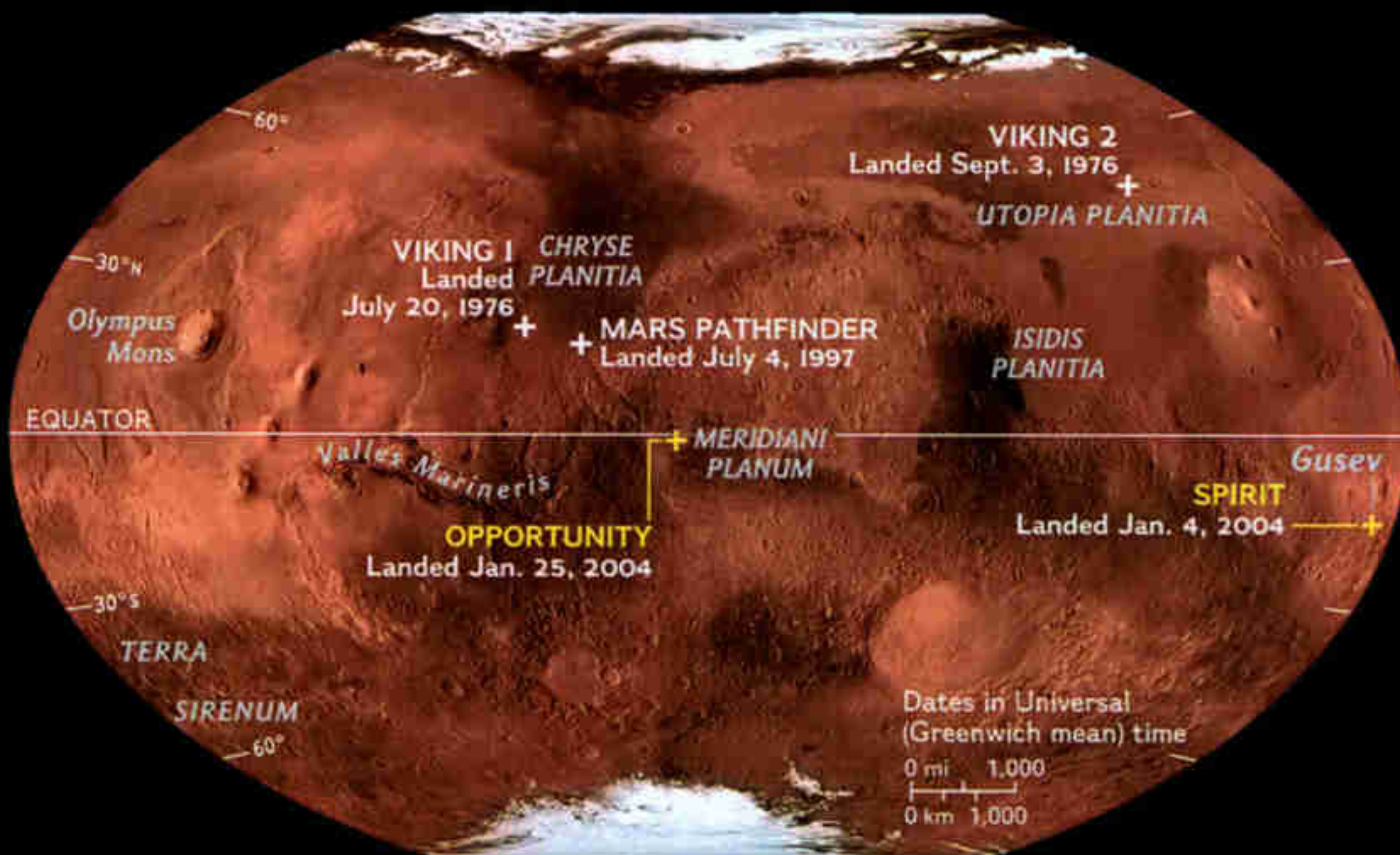
5 Thirty feet from Opportunity, an outcrop along the wall of Eagle crater shows layering similar to

that seen in water-deposited rock on Earth. The rust-colored square highlights a rock called Stone Mountain.

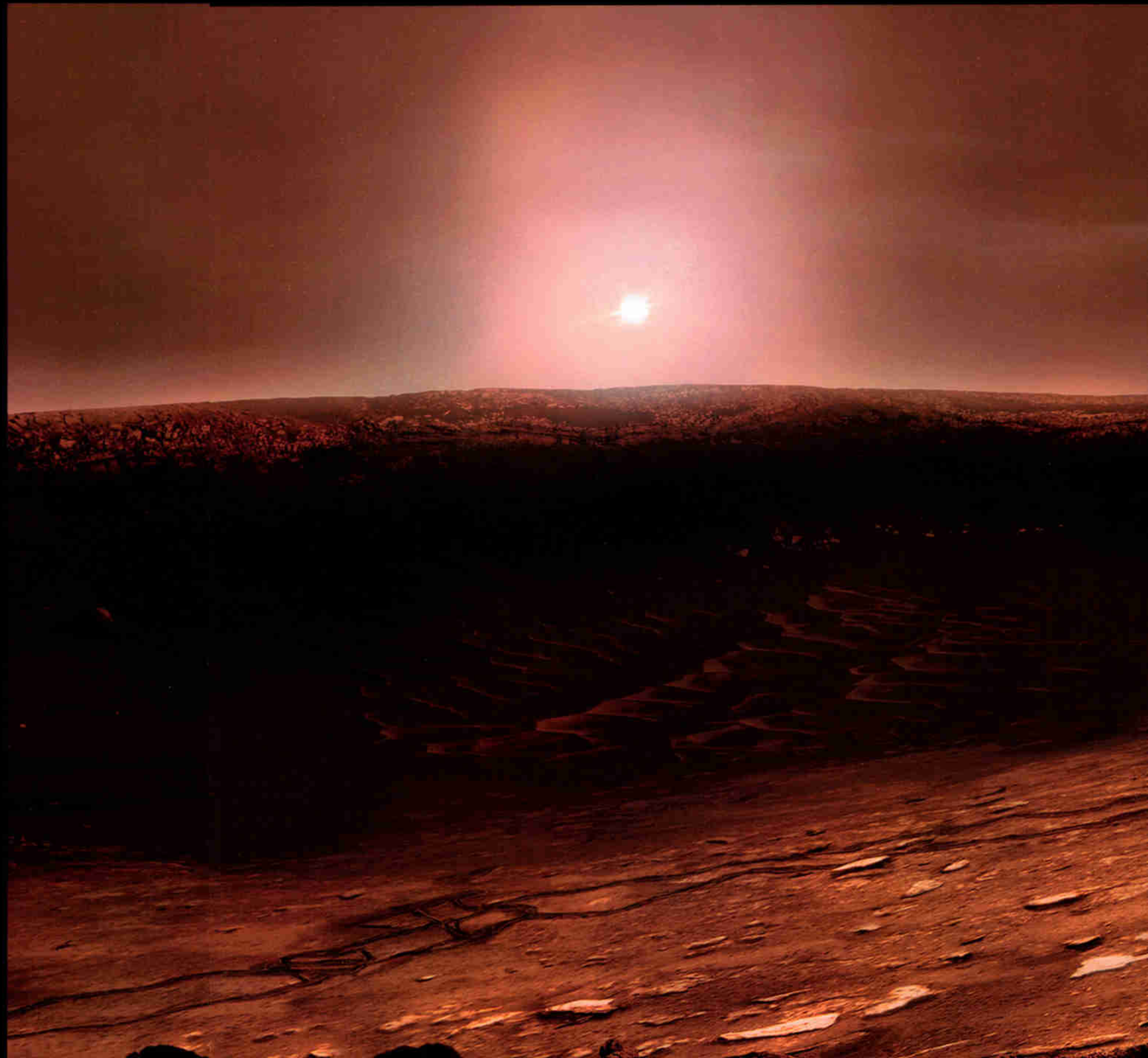
6 A close-up of Stone Mountain reveals an area (indicated in gray) bearing hematite—an iron-rich mineral that can form in water.

7 Opportunity's microscopic imager recorded a hematite sphere, or "blueberry," weathering out of the rock. The foot of the rock was littered with blueberries, the handiwork of ancient water.

Opportunity (art, right) and Spirit stand almost five feet tall, carrying solar cells, cameras, radios, and an instrument-laden mechanical arm. They touched down near the Martian equator, halfway around the planet from each other (map, below).



1: NOEL GORELICK AND CHRIS EDWARDS, ARIZONA STATE UNIVERSITY; NASA/JPL 2: NASA/JPL AND MALIN SPACE SCIENCE SYSTEMS (MSSS) 3: ANDREW JOHNSON, JPL; NASA 4: NASA/JPL AND MSSS 5: NASA/JPL AND CORNELL 6: NASA/JPL AND CORNELL 7: KEN HERKENHOFF, USGS; NASA/JPL, CORNELL
MAP: IMAGE BY MSSS; DATA FROM NASA/JPL AND MARS ORBITER CAMERA (MOC) AND MOLA SCIENCE TEAMS; NATIONAL GEOGRAPHIC MAPS. ART (RIGHT): MAAS DIGITAL; CORNELL; NASA/JPL



...To the Surface



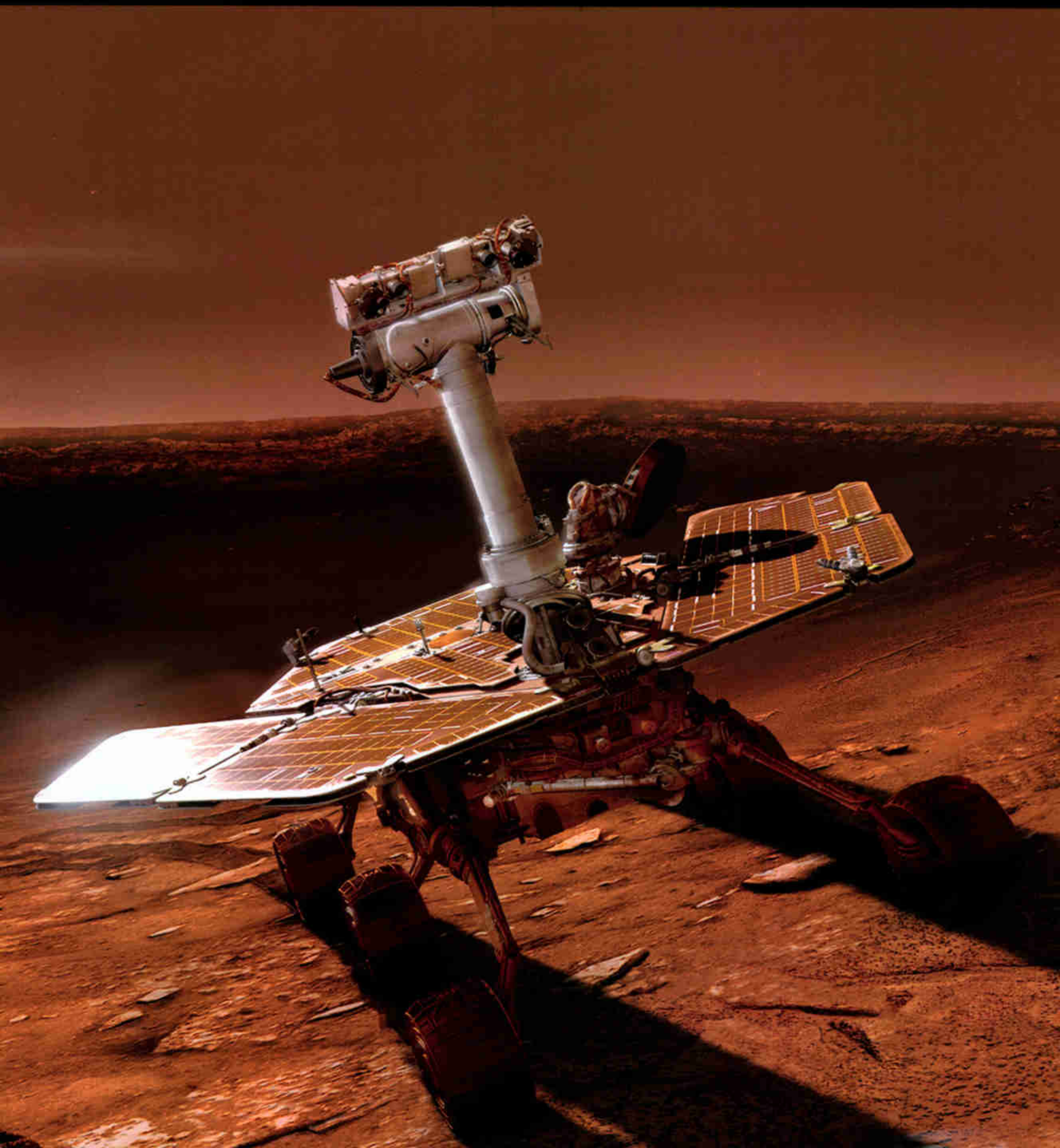
5 | 15 feet



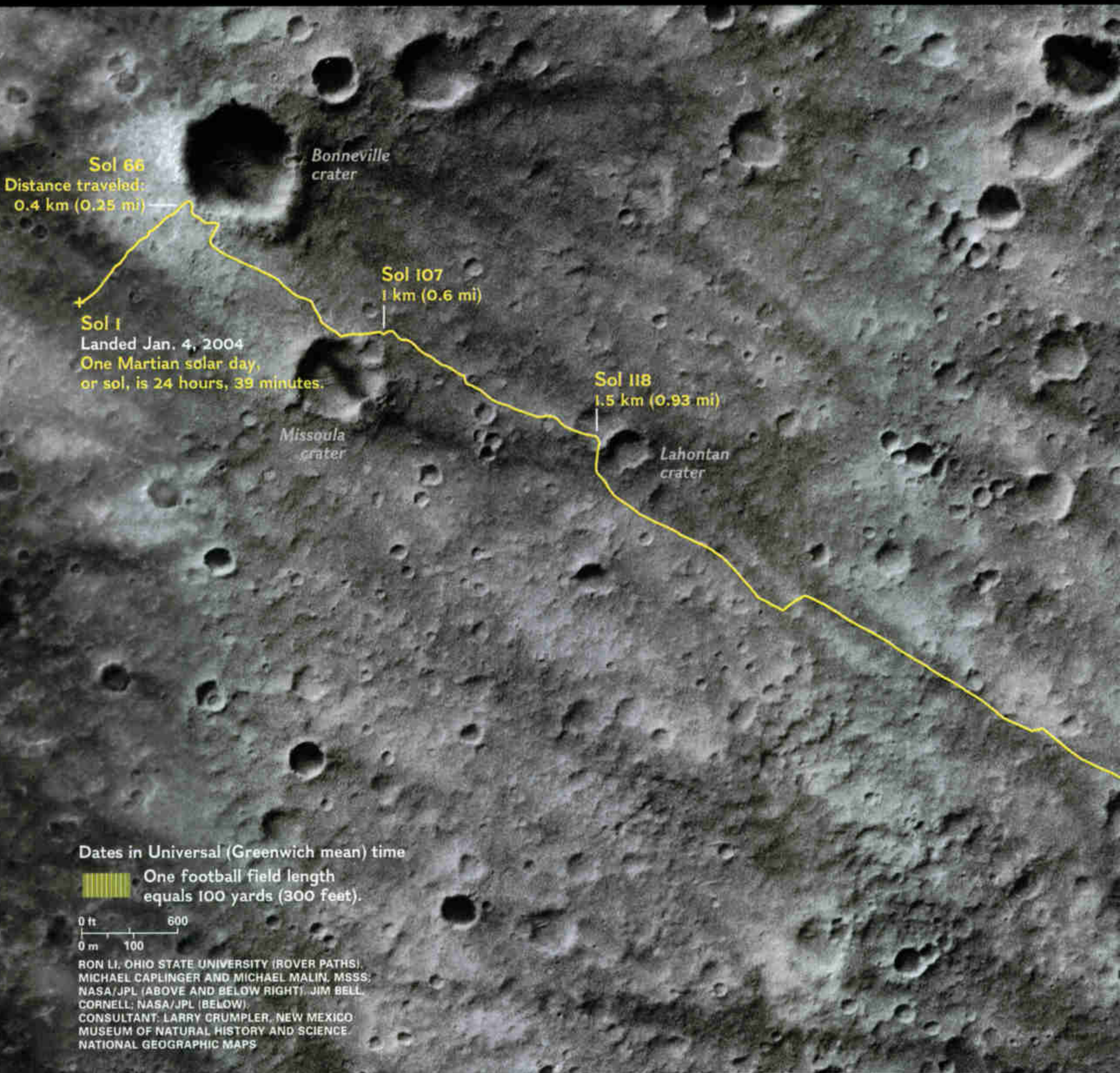
6 | 1.3 feet



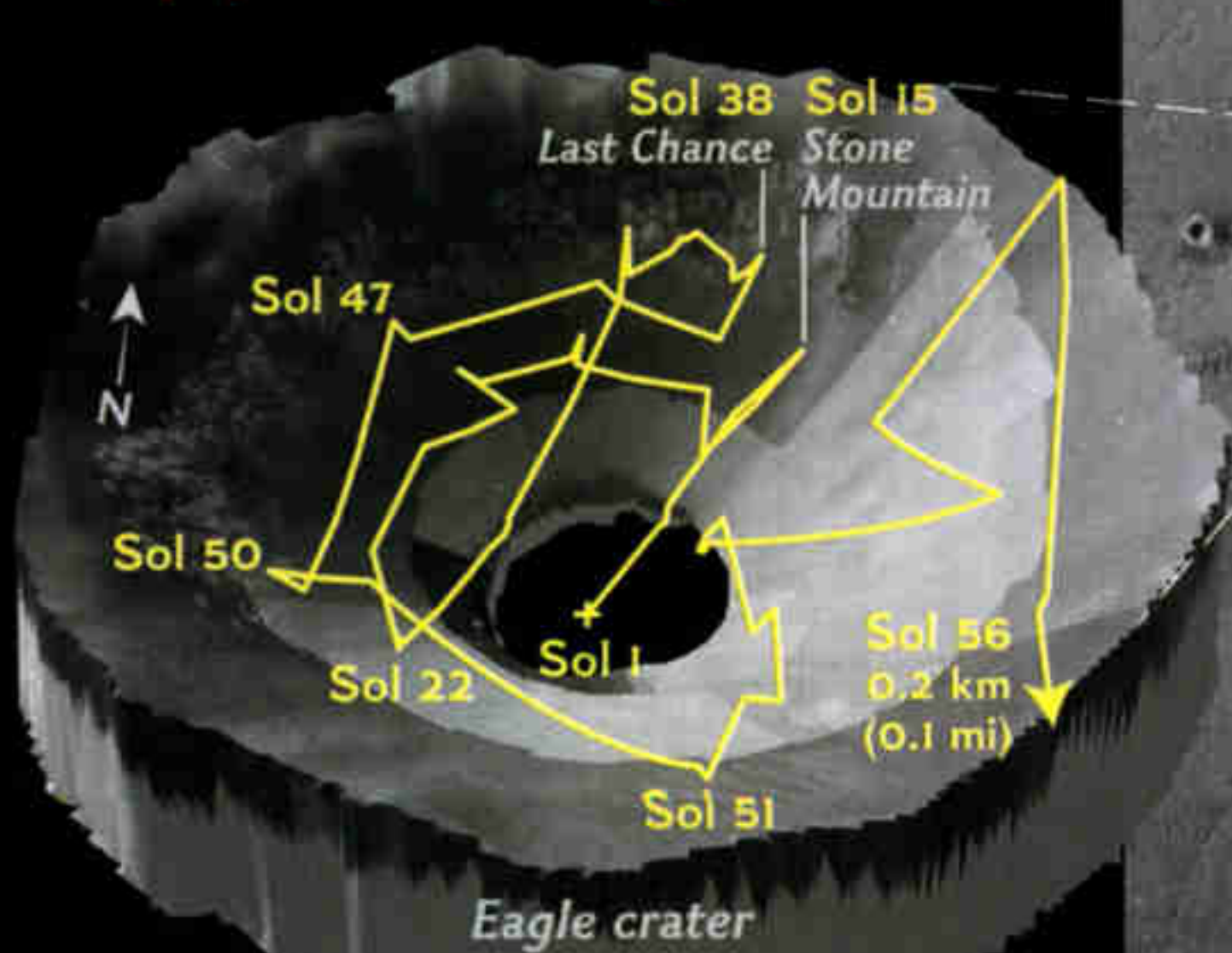
7 | 1.3 inches



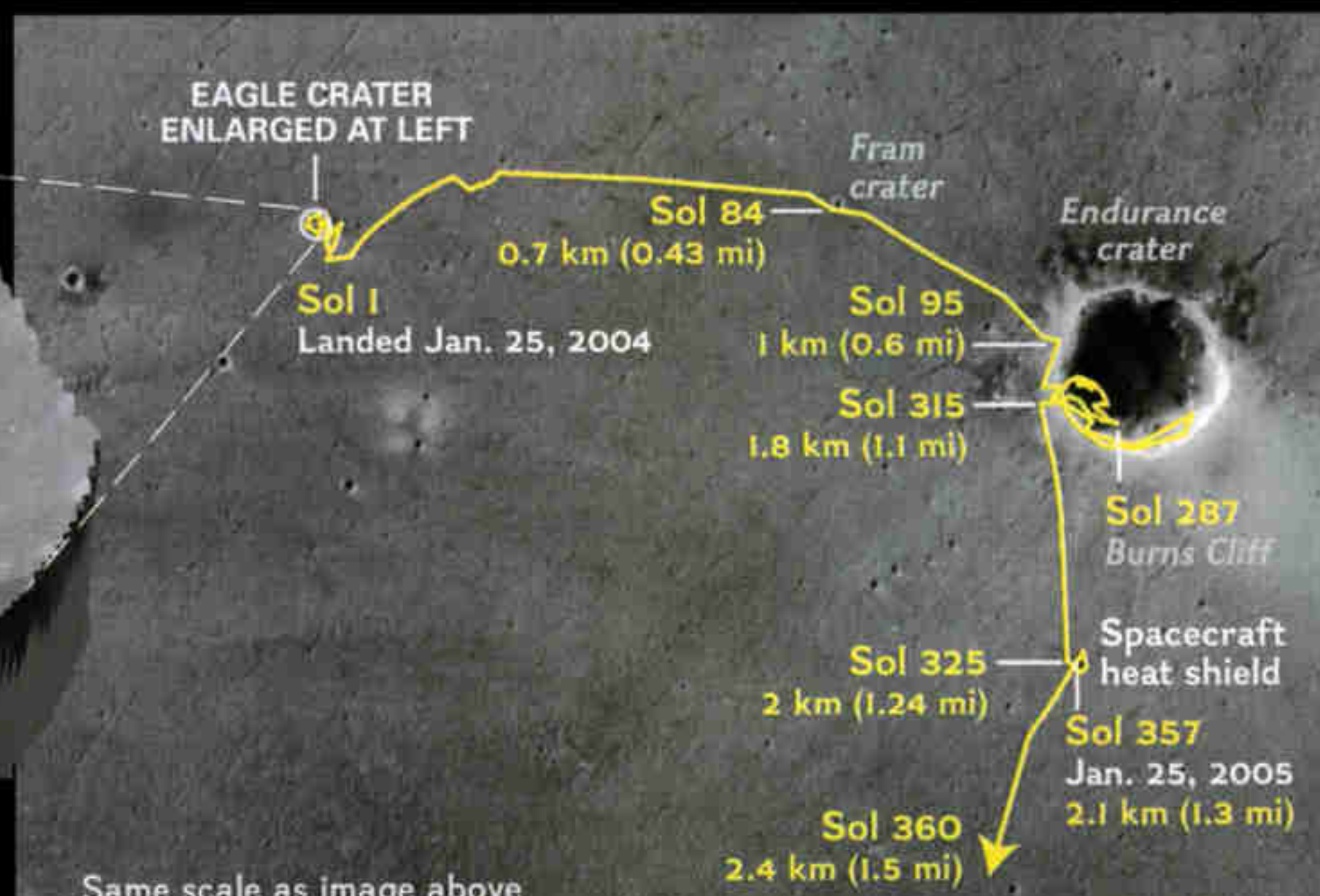
Spirit



Opportunity



Scale varies in this perspective.
Diameter of Eagle crater is 20 m (65 ft).



Same scale as image above



One Year, Two Treks

Moving in fits and starts, no more than a few hundred feet a day, Spirit drove two and a half miles in its first year (above). Opportunity stuck closer to home for most of that time (map and enlargement, left). But it is now covering distance faster as it heads south. Careful management of the rovers' solar-charged battery power has been key to their endurance: They keep their solar panels turned toward the sun and shut down some instruments at night to conserve power.

(Continued from page 60) the confidence to interpret wide stretches of geography seen from afar. Powell climbed mile-high cliffs while scrutinizing their colorfully layered limestone, sandstone, marble, chert, volcanic rock, and gneiss. Once on top he could gaze across tens of miles of canyonland, sketch maps in his notebook, and knowingly label distant strata from their colors and continuities. Similarly, thanks to reports from the six-wheeled rovers exploring two small patches of Mars, researchers can make sense of the sometimes ambiguous images from satellites orbiting high above.

Take the sinuous channels visible on Mars's parched countenance. They so resemble huge, dry riverbeds that flowing water in some long-ago epoch seemed a very good bet. But proof was lacking. Some scientists argued that frigid surges of liquid carbon dioxide might have carved the channels. Others said Mars was never warm enough for more than the briefest pulses of water because it seems to lack the extensive limestone and other carbonate minerals that a warm, carbon-dioxide-rich atmosphere would have left behind. "I spent my career describing water on Mars," says Mike Carr, a geologist at the U.S. Geological Survey in Menlo Park, California. "But we just couldn't find the carbonate. I was starting to tell people my whole career maybe was ashes."

No longer. The rovers, Spirit and Opportunity, have found direct and convincing evidence that water sometimes sloshed across Mars, almost certainly during the planet's earliest epoch well over three billion years ago. Perhaps only puddles, streams, and flash floods came and went, drying repeatedly. But it's looking more and more likely that liquid water was once abundant, though short-lived. Even oceans, however ephemeral, remain a possibility, and on a planet once warmer and wet, life—past or present—is a tantalizing prospect.

The solar-powered robot explorers that have provided this ground truth rarely cover more than the length of a football field between sunrise and sunset. A flesh-and-blood geologist in a spacesuit (sent to Mars at a cost of untold billions) could do in a week what either machine has managed in more than a year. But the rovers are the best stand-ins yet for people on an alien planet. "From the start, we wanted a view with human visual resolution," says Jim Bell, a Cornell

Models for Mars...



To help interpret the deluge of data from Mars, scientists seek geologically similar environments on Earth. The 270-million-year-old sediments in a Kansas outcrop (above) resemble rock layers Spirit found in the Columbia Hills (foreground image). The acidic waters of Spain's Río Tinto region (right) and

University astronomer and lead scientist on each rover's panoramic camera, or Pancam. The Pancam has stereo vision, like people, and its lenses ride at about human height: five feet up on a mast rising above a deck of solar panels.

For Larry Soderblom, a geophysicist and planetary specialist with the USGS in Flagstaff, Arizona, the view through those lenses triggers what he calls an enchantment. The detailed images of alien vistas, after one pores over them for days or weeks, commandeer the imagination. In one corner of the brain, says Soderblom, "you start to think and believe that you are actually there."

The scientists who send the rovers their daily marching orders often sound as if they're personally crunching across the red planet's surface, taking pictures, eyeballing sediments, and grinding holes.

"Oh wow, look at that!" exclaimed Steve Squyres as a Mars vista unfolded before him one evening late last year. Squyres, the lean and hyperkinetic planetary geologist at Cornell who heads the brain trust behind Spirit and Opportunity, has been saying wow a lot these days, or, more precisely, these "sols," to use the term for the 24 hour, 39 minute Martian day-night cycles. He wears a watch altered to Mars time. He and fellow rover handlers say things like "yestersol." For the first months of the mission Squyres and dozens of other rover scientists even worked on Mars time in round-the-clock shifts at the mission's headquarters, NASA's Jet

Propulsion Laboratory in Pasadena, California.

This evening, ten months after the rovers got down to business, Squyres was back in the Cornell Space Sciences building in Ithaca, New York. About once a day the rovers radio a report home, including digital snapshots and instrument data. Squyres goggled at that day's harvest from Opportunity on an oversize video screen on the wall.

It showed a perfectly framed view from just inside the south lip of Endurance crater, a 430-foot-wide meteorite scar in a vast equatorial plain. The foreground sloped steeply down to the left. To the right the crater's steep rim of blocky, fractured, pale rock curved into the distance. Mission scientists had named it Burns Cliff to honor the late mineralogist Roger Burns, who proposed that water on Mars might have left deposits like those lining the crater rim. A slice of Martian sky arced above.

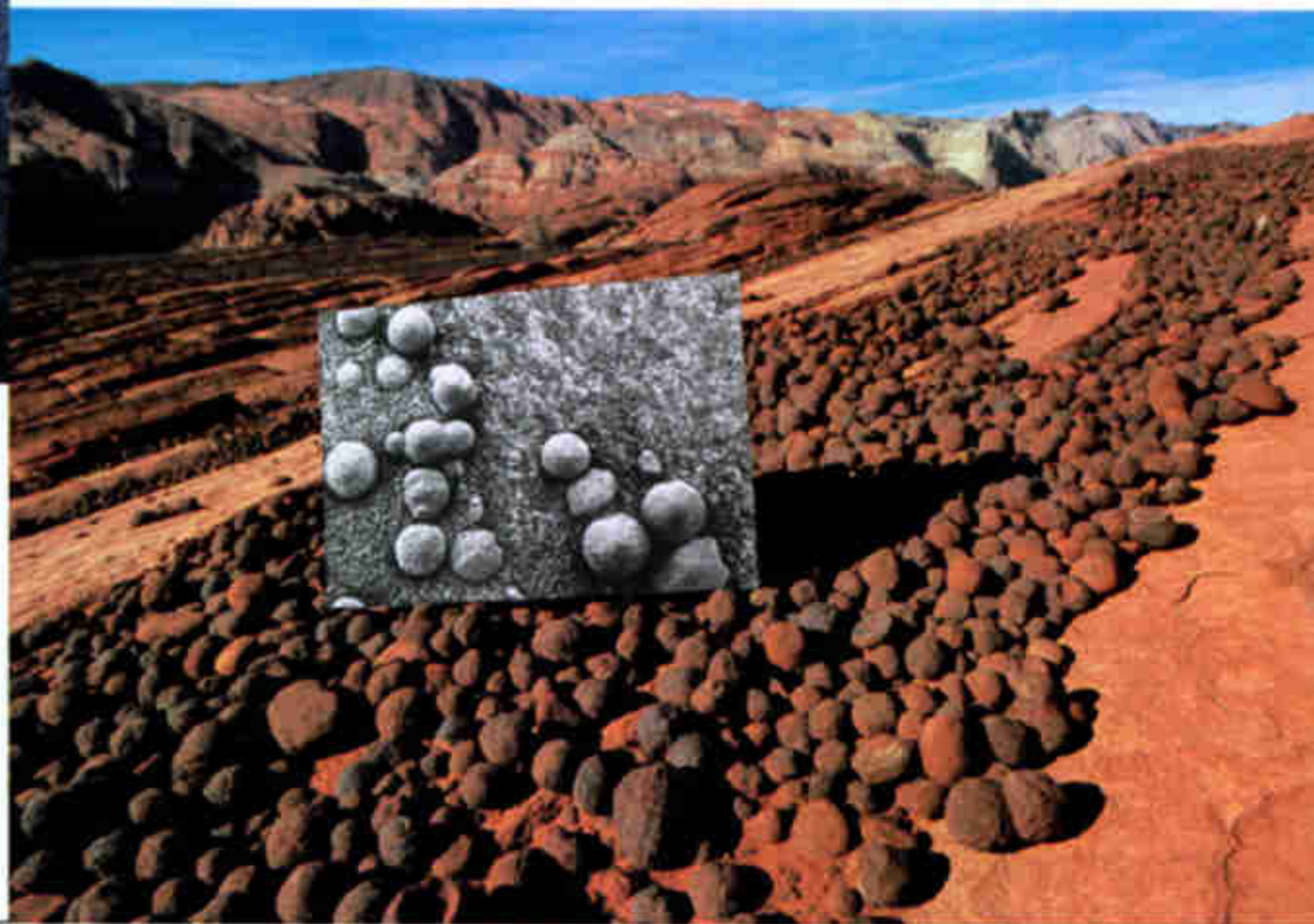
Squyres couldn't contain himself at the view—a planetary geologist's dream. "Here we are in a crater formed in water-laid sediments, navigating sand drifts. We're there. We're rolling on Mars, and we just keep going. It's way, way beyond what we expected."

The rovers are the fruit of a 16-year quest by Squyres—pursued for the past six years with his deputy principal investigator, Ray Arvidson of Washington University in St. Louis—to put a mobile geological instrument package on Mars. The two men spent endless hours testing prototypes in the deserts of the Southwest. They negotiated bureaucratic labyrinths to



...On Earth

the ephemeral salt lakes of Western Australia (above) may resemble the waters on ancient Mars and hold clues to the life that could have existed there. Large iron oxide balls found in Utah's sandstone hills (right) formed in water-soaked rock, as did the smaller spheres seen by Opportunity (black-and-white image).



convince NASA and its paymasters in Congress to fund the mission. In the end NASA decided to send two rovers instead of one, improving the odds of success and raising the total cost to 850 million dollars.

Finally, at the start of 2004, the rovers reached Mars, along with a small armada of other probes, most taking advantage of an unusual orbital alignment that allowed a short, six-month voyage. Some failed, but a European orbiter called Mars Express arrived safely. So did Spirit and then, three weeks later, Opportunity. After slamming into the atmosphere and descending by parachute, each rover inflated a cushion of air bags, fired a retro-rocket, and free-fell the last 25 feet or so to a bouncing, rolling landing. They touched down on opposite sides of Mars, at two very different sites.

From space, Spirit's landing spot in Gusev crater looked like a perfect place to find old lake sediments. The 95-mile-wide bowl lies 15 degrees south of the equator at the edge of the planet's southern hemisphere highlands. An immense channel empties into it. It has all the signs of being an ancient lake bed.

But after Spirit's January 4 landing, the water hunters' hopes—for example, that Gusev might hold a sea of ancient dried mud—evaporated. The probe gazed upon a rugged, rock-strewn plain. "It was just massive, hard, crisp, basaltic lava," Squyres says. Any lake bed was buried long ago by the lava flows. Spirit's first close look at

nearby rocks found only traces of waterborne minerals, hinting that the rocks got damp from time to time but were never steeped in water.

The rover sent home a beguiling but frustrating panorama showing a line of low hills to the southeast. Some 300 feet high, the hills clearly predated the lava flows, which had only lapped against their flank. They might have had a different, wetter history, but they were two miles off, several times farther than Spirit's expected range. A few days after the landing, Jim Bell looked wistfully at the image of the hills and wondered whether the rover could reach them.

After Spirit checked out a nearby crater named Bonneville, also encrusted in basalt, her bosses sent her across the wilderness. She—the scientists regard both rovers as female—beelined toward the distant range, named the Columbia Hills after the fallen space shuttle. Spirit had a vexing early stumble when a computer memory kept overflowing (fixed when mission control in Pasadena radioed a new program), but now she did not flag. Operators tweaked computerized marching and hazard-avoidance routines to speed the rover across the rocky flat. Some sols she went more than 400 feet. "We were roaring across the plains as fast as we could go," says Doug Ming of NASA's Johnson Space Center.

On sol 156—in mid-June on Earth—Spirit reached the hills. "It was like another continent," says science team member Larry Crumpler, a geologist at the New Mexico Museum of Natural History and Science. Just short of the hills lay a

boulder that the team named Plymouth Rock, marking Spirit's arrival at a promising land.

The Columbia Hills appeared to be built of volcanic ash or meteorite impact debris. But unlike the hard stone of the volcanic plain, these rocks were often soft, almost chalky, yielding easily when Spirit bored into them. Some seemed to be rotting. The texture alone implied that water once percolated through the rock, a conclusion that deepened when Spirit discovered telltale minerals. First she detected gray crystalline hematite, an iron oxide that is often—but not always—the handiwork of water. Then, in December 2004, came the clincher: an iron mineral called goethite, a sure sign of past water. Long ago, these hills were clearly soaking wet.

It was a triumphant find, but Opportunity had trumped it months before. Mission scientists had chosen Opportunity's landing site on a dead-flat equatorial plain known as Meridiani Planum because orbiting spacecraft had detected the infrared signature of gray hematite on a patch of ground hundreds of miles across. While hematite was a surprise at Gusev, here it was the lure all along. On arrival, Opportunity had bounced 220 yards across the nearly featureless terrain, then plopped—by pure chance—into an isolated little crater about 65 feet wide.

It was a shot celebrated as a 300-million-mile hole in one almost from the moment the rover turned on its cameras. About 30 feet away along the rim of what came to be called Eagle crater was an exposure of pale bedrock. After trundling over to the outcrop, the rover "ratted" into its surfaces (using its diamond-toothed grinder called the RAT, or rock abrasion tool), scanned the freshly exposed rock to identify its minerals and chemical makeup, and scrutinized it with multiple cameras including a microscopic imager. The result is a treasure-house of evidence that this corner of Mars was once drenched.

The porous rock is rich in water-deposited minerals: magnesium sulfates similar to ordinary Epsom salts, bromides, chlorides, and iron-rich compounds. Strewn over the ground or eroding from the rock were gray spheres, from smaller than peppercorns to the size of peas, which soon came to be called "blueberries." The hematite-rich blueberries explain the gray layer seen from orbit, which had attracted the mission planners to Meridiani Planum in the

first place. The scientists concluded that all these minerals were left behind when salty groundwater seeped through sand and porous stone.

Best of all, a foot-long section of bedrock called Last Chance bore distinctively curved layers. Sedimentologists on the team immediately and jubilantly exclaimed: "Crossbedding!" This can form when running water pushes trains of ripples across a sandy bottom, creating a pattern that is buried and preserved by later sediments. "You can go out to your nearest beach or creek and take a shovel and dig in and see some of these same kinds of structures," says Dave Rubin, a USGS sedimentologist. Another scientist compared the undulations to smiles. And smiles are what they evoked.

In the following months Opportunity found sediments formed or altered by water all around its landing site, particularly in Endurance crater, where they stack up in deposits up to 30 feet thick. Nobody can be sure what the ancient water bodies at Meridiani were like. But, inspired by the ground truth from the rovers, scientists are finding clues in images of Mars from orbit and even in odd corners of our own planet.

Satellite images, for example, show that light-colored outcrops extend well beyond the hematite zone that drew mission planners to Meridiani. Before the landings, Brian Hynek of the University of Colorado had doubts about any ancient lake. The outcrops and even the hematite, he thought, could have formed from piles of volcanic ash untouched by water. But then, at Eagle crater, Opportunity found the same pale stuff as in the distant outcrops, along with abundant evidence that water was responsible. If the entire pale expanse is the legacy of water, Hynek now calculates, the wet region could have been as big as Earth's Baltic Sea.

Deep gorges seen from orbit suggest that this bedrock may be 500 yards thick in places. Did Meridiani once hold an actual sea, with open water? "You can't tell," says Hynek. "But water was not a local exception, and there was a lot of it."

Marjorie Chan drew a connection all the way from Opportunity's landing site to the canyonlands of southern Utah. Chan, a geologist at the University of Utah, studies the little round rocks that curio shops out West sell as "moqui marbles," after the Hopi Indian belief that they are playthings for the spirits of their ancestors,

Watermarks

Images from orbit trace water on Mars today and in the distant past. Europe's Mars Express orbiter imaged layers of ice near the north pole (right), while NASA's Mars Global Surveyor found a fan-shaped sediment formation eight miles across (bottom), probably left by an ancient Martian river emptying into a lake.

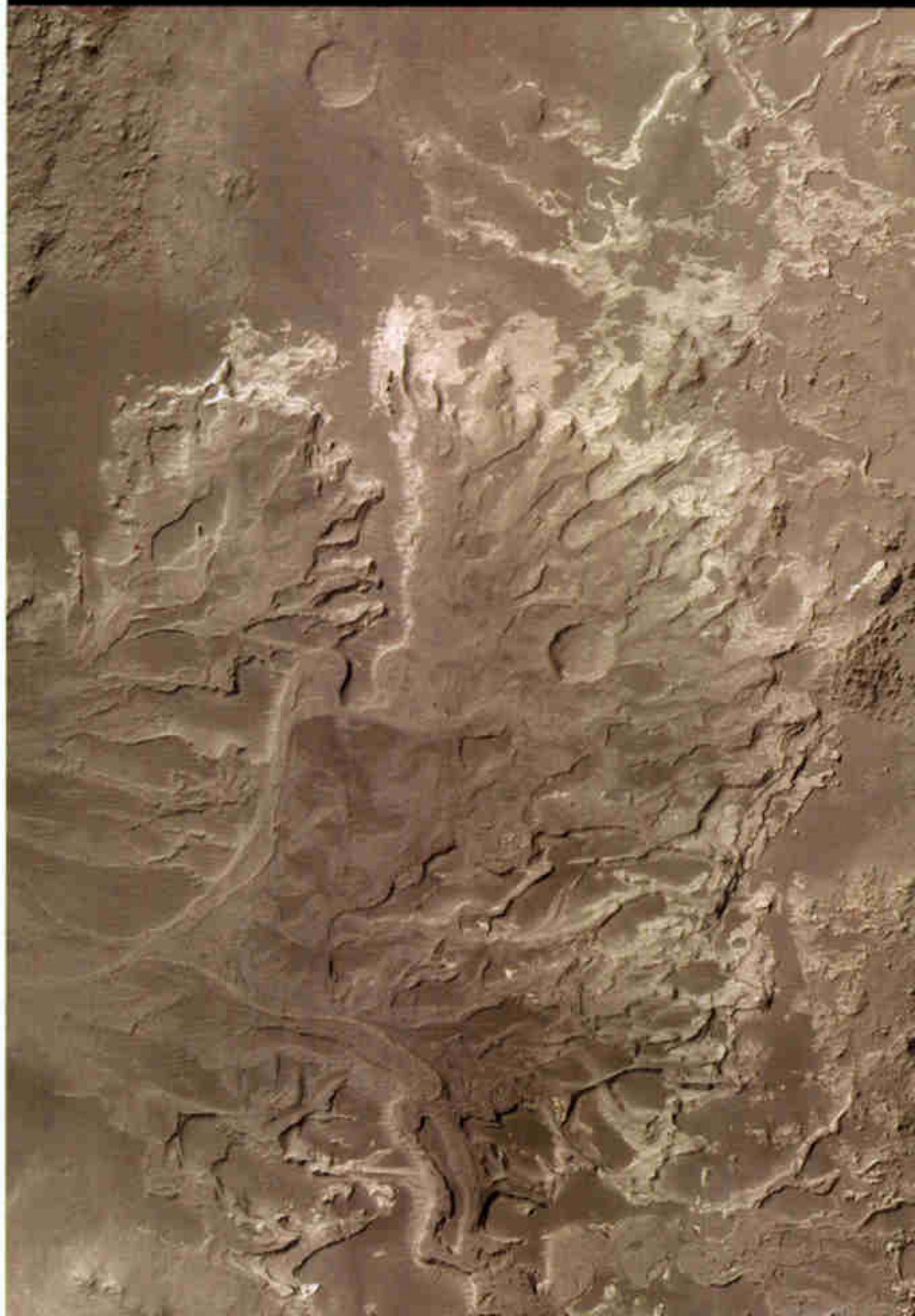
the *moqui*. Her group has found that the marbles, strewn by the millions across the Utah red rock, are made of sandstone cemented with iron-rich minerals that precipitated from groundwater, such as hematite and goethite.

In 2003, when Chan's team heard that a Mars rover was headed for a hematite-rich landing site, the scientists predicted it might find such marbles there. Their paper still had not appeared when, bingo, the blueberry photos from Mars arrived. "I shrieked," says Brenda Beitler, a grad student. Chan says her first thought was, "Oh my gosh, this stuff we've been thinking about is really true."

They quickly wrote a new paper on the Utah connection to Martian blueberries, which raised an alluring long-shot possibility. Underground bacteria may speed the formation of the Utah marbles, leading to speculation that ancient Martian microbes might have helped cement the blueberries of Meridiani. More important, the years of science Chan's group put in to understand how *moqui* marbles grow could help Mars experts calculate how much water it took to nurture the blueberries in Meridiani's hollows.

News that the Meridiani minerals include a sulfate compound called jarosite triggered other aha! moments. On Earth, jarosite forms only in wet, acidic settings—in runoff from mines, for example. Johan Varekamp of Wesleyan University in Connecticut realized that the Mars minerals closely match those of a volcanic region he has studied on the Chile-Argentina border, where streams colored bright red by fresh hematite run into an acid lake below a volcano. That setting may not sound friendly to life, but Varekamp notes that despite their high acidity "these terrestrial river and lake fluids are teeming with microbial life."

Acid streams and lakes on Mars would clear a long-standing obstacle to the theory that it had a warm, wet past: the lack of the carbonate





What Next?

In December Opportunity reached the remains of its heat shield, at center and left. A crater, right, formed where the shield hit the ground after it was jettisoned at high altitude. Meanwhile, Spirit was climbing the Columbia Hills. Both rovers were “in amazingly good shape for their age,” says NASA’s Jim Erickson.

minerals that should be left if the planet had a warming blanket of carbon dioxide. Water made acid by sulfur from volcanoes seething on early Mars would explain the puzzle, because acid suppresses carbonate formation.

Jarosite, the mineral that points to an acid environment, also implies that the wet times came to a quick end. If the climate had remained humid for long after the jarosite formed, the mineral would have broken down and would not be found today. The layered sediments at Meridiani may be hundreds of yards thick, but if each layer formed in a cycle of wetting and drying, they could have built up in less than half a million years. That’s a mere instant in the 4.5-billion-year history of Mars.

How could the water have disappeared so fast? Where did it go? Maybe some was lost for good when it evaporated and rose high in the atmosphere, where radiation split it into atoms that escaped to space. Some of it remains on Mars, frozen at the poles. And much may be hiding underground, possibly in glaciers buried

beneath the dust. Confirmation may come from Europe’s Mars Express orbiter. It carries a 130-foot antenna that will probe the terrain with radar, looking for water or ice buried up to a mile beneath the planet’s crust.

Mars Express may already have sniffed out indirect evidence for subsurface moisture on Mars: tantalizing hints that methane gas is wafting into the atmosphere. A comet impact or hidden volcanic activity could have released the gas. But methane—called swamp gas on Earth—could conceivably be a sign that Martian microbes survive underground in damp pockets of subsoil.

The rovers themselves have soldiered on, to the surprise of their handlers back on Earth. After an exhausting eight months at JPL, the first four on sleep-disrupting Martian time, the science team had reached its limit. Squyres and the others went home, coordinating their work by phone, computer, and videoconferencing. The rovers were well beyond their anticipated life span by then, and engineer Eddie Tunstel of JPL’s Robotic Vehicles Group marveled, “I thought by now something would just lock up.”

After a year a few signs of age had set in. The motor in Spirit’s right front wheel began to malfunction, then seemed to recover. One instrument on Opportunity succumbed after a winter of extreme cold, down to 170 degrees or so below zero F some nights last October. But both rovers defied predictions that dust buildup on the solar



panels would fatally sap power. In fact the rovers got unexpected power boosts when passing Martian whirlwinds dusted off their solar panels. While Spirit continued to follow the story of water in the ridges and dales of the Columbia Hills, Opportunity set out to roam as far as her aging mechanisms could take her.

In December Opportunity left Endurance crater and headed south. Within 200 yards she encountered the wreckage of her own heat shield, which had smacked into the ground after the spacecraft shed it high in the atmosphere. Nearby was another Martian surprise: a metallic, pitted rock the size of a basketball. It was a meteorite, the first to be seen on another planet. “I’ve told the team we shouldn’t linger here long,” Squyres joked. “This is clearly the place where large metal objects fall from the sky.”

By April Opportunity had ventured two miles farther south, toward rugged country dubbed the “etched terrain” and thought to consist of sulfate deposits heavily eroded by wind. “Imagine, billions of years of wind eroding the landscape,” Squyres says. He wants to explore the exposed bedrock layers and any history of water they preserve.

In the years ahead, even more ambitious missions will follow Spirit and Opportunity. NASA’s plans include a new, sharper-eyed orbiter to arrive in 2006, a lander that would dig for near-surface ice close to the north pole in 2008, and another rover mission, the Mars Science

Laboratory, in 2009 or later. Likely to be nuclear-powered so that it could operate around the clock, cover long distances, and send a torrent of data almost continuously, this rover (or rovers) would carry an onboard lab that could search for clues to life. The European Space Agency also hopes to add to the traffic on Mars with its own rover, called ExoMars, as early as 2011.

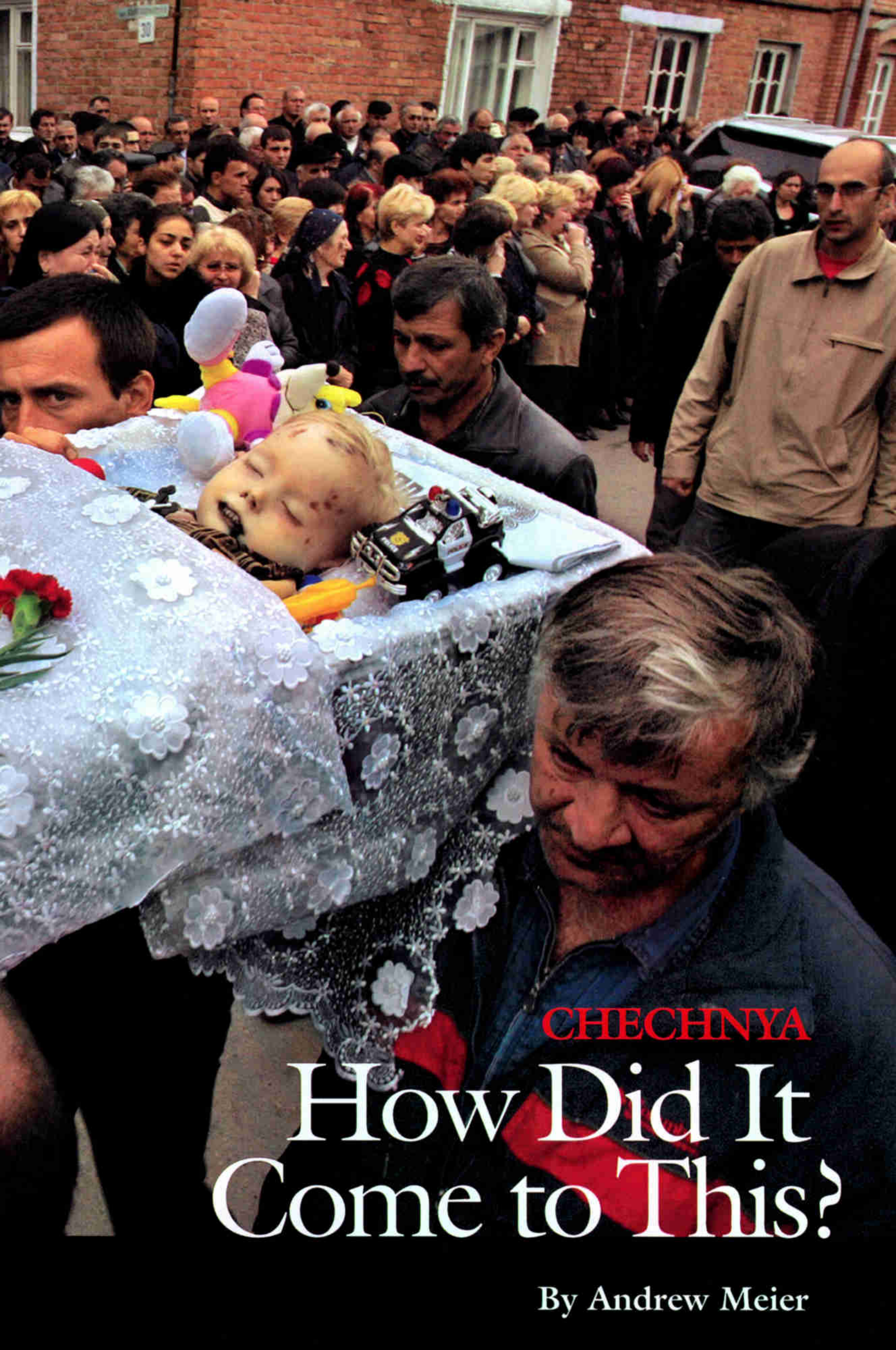
After that things get fuzzier, but in ten years or so both NASA and the Europeans have tentative plans to bring chunks of Martian rock back to Earth. In one NASA concept, an advance party of several rovers would gather samples and load them onto a cargo craft that would bring them back to labs on Earth. And eventually, if society ever decides the cost of a human mission is worth it, people will tread the reddish dust of Mars and search for signs of life with their own hands and eyes.

As for John Wesley Powell, sooner or later his legacy as conqueror of the Grand Canyon will be fully realized on the red planet. Mars has its own canyon, far grander than ours: Valles Marineris, as long as the United States is wide, hundreds of miles across, and six miles deep. Someday, machines or people—the heirs of the robot geologists now on Mars—will march into that great gorge to gather more ground truth. □

A MARS NEVER DREAMED OF Experience its Sights & Sounds and zoom in on Valles Marineris, the solar system’s largest canyon. Then join our Forum to debate the question: Is there life on Mars? Go to nationalgeographic.com/magazine/0507.



The innocent keep dying as the brutal decade-long battle for independence in the Russian republic of Chechnya spills across the Caucasus. Two-year-old Georgy Daurov was among hundreds of hostages killed last year when Chechen-led terrorists seized a school in Beslan in the nearby republic of North Ossetia.



CHECHNYA

How Did It Come to This?

By Andrew Meier



Malika—not the real name of a young Chechen doctor and mother of two—has lost nearly every member of her family to a vicious war of secession that has turned her homeland into a hell that would stretch Dante’s imagination. A Russian bomb killed her mother in 2001. Her father survived the blast but couldn’t withstand the horror surrounding him and soon succumbed to illness. Russian forces hauled off her brother and held him at a grim makeshift jail for five months. Through the help of the Red Cross he was released, only to die of a heart attack a short time later.

The worst blow came on a spring night in 2002. At one o’clock in the morning, heavily armed men in masks and helmets broke into Malika’s apartment in Grozny, the capital of Chechnya, and took away her husband. “To this day I don’t know if he’s alive or dead,” she says. Local officials have offered no help. At the Grozny prosecutor’s office, her husband’s file is but one of thousands that bear a single heading: “Disappeared.”



MITRY BELIAKOV (ABOVE); IVAN SEKRETAREV, AP/WIDE WORLD PHOTOS (PRECEDING PAGES)

THE DESTRUCTION OF GROZNY

A Russian soldier and a military doctor stare into ruined space as tanks roll through Chechnya's capital, which fell in February 2000, after the fiercest shelling and bombing of a European city since World War II. Surviving Chechen rebels fled to the mountains, where they carry on a guerrilla war.

understood the roots of the terror unfolding in the Caucasus, the mountainous region on their country's southwestern flank that includes Chechnya and other predominantly Muslim republics within the Russian Federation.

For more than a decade the war in Chechnya has been a bloodbath in which both Russian soldiers and Chechen separatists have paid little attention to the niceties of the Geneva Conventions. In 1991, buoyed by the tide of nationalist movements rising across the U.S.S.R., Chechen Dzhokhar Dudayev, a little-known former Soviet air force general, mounted a secessionist campaign and by year's end declared his ancestral home independent. Moscow condemned the move, fearing that if Chechnya were allowed to secede, other republics would follow suit. "We cannot stand idly by as a piece of Russia breaks off," declared Russian President Boris Yeltsin, "because that would be the beginning of the collapse of the country."

On New Year's Eve 1994, Yeltsin sent hundreds of tanks into the center of Grozny, launching a conflict that continues to this day. The fighting has taken between 100,000 and 300,000 lives and displaced upwards of half a million Chechens in a republic that spans just 5,800 square miles—an area slightly larger than the state of Connecticut. Grozny has suffered the worst destruction in Europe since World War II.

Chechnya is the bleeding heart of the Caucasus, which stretches 750 miles from the Black to the Caspian Seas. This has been coveted ground since the days of Genghis Khan: Warriors have sought the sanctuary of its mountains; traders have jockeyed for access to its ports; and, most recently, oilmen have converged on the petroleum fields of the Caspian. Its Russian name, Kavkaz, conjures a potent genie—not only a crossroads of tumult, but a realm of romance. These are the perilous lands where brides are still kidnapped, blood feuds are fierce, and a centuries-old struggle for sovereignty rages on.

Malika carries her grief with quiet dignity. But the despair that hangs like a pall over this war-torn enclave has driven some Chechens—including women—to commit desperate, horrific acts. On the first day of September 2004, 32 Chechen-led terrorists seized Middle School Number One in the town of Beslan in the nearby republic of North Ossetia. The 52-hour siege that followed marked a new low in the annals of terrorism. Some 330 people died, more than half of them children.

As Western news anchors struggled to pronounce the unfamiliar place-names, their viewers watched in disbelief, unable to grasp how human beings could descend to such depravity. Russians, too, watched the tragedy in horror, yet they



TROUBLE IN THE CAUCASUS

Russia's grip on the fractious, largely Muslim republics on its southwestern edge grows more precarious as fallout from the Chechnya war spreads. Bombings, kidnappings, and revenge killings by both sides are destabilizing the region. Russian leaders blame global Islamic terrorism, but most observers cite nationalism and ethnic rivalries.

- Area of predominantly Muslim population
- Terrorist act, 1996-2005 (some symbols represent multiple attacks)
- Internally displaced persons, 2004
- Oil pipeline

0 mi 25
0 km 25

TERRORIST ACT SOURCE: TERRORISM KNOWLEDGE BASE, NATIONAL MEMORIAL INSTITUTE FOR THE PREVENTION OF TERRORISM, OKLAHOMA CITY. NATIONAL GEOGRAPHIC MAPS

CHECHNYA'S HISTORY OF CONFLICT

Armed resistance and a demand for autonomy has shaped life in Chechnya since Russian troops invaded the Caucasus in the 1720s. The expansion of tsarist Russia, a bastion of Orthodox Christianity, coincided with the rise of Islam in Chechnya—a religious divide that has fueled nearly three centuries of Chechen revolt.

1830s-1850s

Imam Shamil

With Chechen and other fighters, Muslim leader Shamil battled Russia's invading army for 25 years. With Shamil's surrender in 1859, the formerly independent ethnic enclave became part of Russia's empire.



1923

Autonomous Region

After the fall of tsarist rule in 1917, a Soviet delegation joined Chechens (below) to mark Chechnya's new status as a separate ethnic region. Chechens later rebelled against forced collective farming.



1944

Mass Deportation

Suspicious of Chechen loyalties during the Nazi invasion of the Caucasus in 1942, Soviet leader Joseph Stalin ordered the exile of 500,000 Chechens to Central Asia. Up to a third of the deportees died in transit. Most Chechens view the deportation as an act of genocide. Not until 1957, under the de-Stalinization program of Nikita Khrushchev, were the former inhabitants allowed to resettle in the Caucasus.



WAR'S GRIM TOLL IN CHECHNYA

Population (most recent estimates)
 1989: 1,100,000
 2002: 784,000
 Killed (since 1994, military and civilian)
 100,000-300,000
 Currently displaced (as of June 2004)
 210,000
 Abducted and "disappeared" (since 1999)
 3,000-5,000
 Unemployed (as of June 2004)
 335,000
 Russian military and security forces (as of March 2005)
 80,000

1991

Breaking Away

As the Soviet Union began to collapse, former air force general Dzhokhar Dudayev (below) led a movement that toppled communist rule in Chechnya. Soon after, he declared Chechnya an independent state.



1994-1996

First War

Expecting an easy victory, Russian forces invaded Chechnya in December to reassert federal rule. Two years later the humiliated troops withdrew, unable to hold the heavily damaged capital of Grozny (below).



1999 to present

Second War

A raid into Dagestan by Chechen-led Islamic extremists ignited a new Russian offensive. Despite retaking Grozny and rounding up suspected rebels (below), Russian forces continue to fight for control.



2004

Beslan Atrocity

The Chechnya conflict regained the headlines in horrific fashion last September when terrorists demanding removal of Russian troops from Chechnya seized hostages at a school in Beslan in North Ossetia. The ensuing firefight between terrorists and security forces and the detonation of bombs in the school killed some 330 people, half of them children. Chechen warlord Shamil Basayev took credit and vowed further attacks.



In the post-Soviet era the mountains have separated Russia from the countries of Georgia, Armenia, and Azerbaijan to the south. The lands north of the massifs, a linguistic and ethnic maze known collectively as the North Caucasus, comprise seven Russian republics: Adygeya, Karachayevo-Cherkesiya, Kabardino-Balkariya, North Ossetia, Ingushetiya, Chechnya, and Dagestan.

Among this profusion of ancient peoples, amid the labyrinth of ethnic and religious traditions, one group always seemed to stand apart: the Chechens. Few have yearned more fervently, or more militantly, for freedom. Since their first skirmish with Peter the Great's cavalry in 1722, Chechens have struggled to escape Russian

domination. During a journey across the Caucasus in 1858—a time when the Muslim mountaineers were waging holy war against tsarist rule—the writer Alexandre Dumas noted their martial spirit: “All these mountain fighters are fanatically brave, and whatever money they acquire is spent on weapons. A Chechen . . . may be literally in rags, but his sword, dagger, and gun are of the finest quality.”

Even in the gulag, the Soviet Union's prison labor camps, the Chechens stood out. Dissident Alexander Solzhenitsyn, in *Gulag Archipelago*, wrote of them with envy: “There was one nation which would not give in, would not acquire the mental habits of submission—and not just individual rebels among them, but the whole



PETER DE JONG, AP/WIDE WORLD PHOTOS (ABOVE); HEIDI BRADNER, PANOS PICTURES



HOSTILE GROUND

Life drains from a wounded Chechen fighter, carried from a street battle in January 1995, when 12,000 Russian soldiers stormed Grozny. Before bombing drove them from the city, rebel bands cut down the invading troops, exposing the weakness of Russia's raw, ill-equipped ground forces. Near the end of the first war, in 1996, a retreating Russian conscript (above) burns his camp to leave nothing for the enemy.

nation to a man. These were the Chechens.”

The roots of the present trouble, like so much of the tension across the Caucasus, began with Joseph Stalin. When the Bolshevik army finally wrested control over the region in the 1920s, Stalin, then nationalities commissar, hatched a scheme to subjugate the restive population: Embed enough ethnic, linguistic, and religious contradictions into the political geography so as to preoccupy the locals and ensure that Moscow's firm hand would be required to maintain order. In the case of the hyphenated republics Karachayevo-Cherkesiya and Kabardino-Balkariya, natural enemies were forced to live side by side. “It wasn't just divide and conquer,” Ali Kazikhanov, editor of the newspaper *Severny Kavkaz*, told me

in Nalchik, the capital of Kabardino-Balkariya. “It was divide, conquer, and tie up in trouble.”

On February 23, 1944, Red Army Day, the entire Chechen and Ingush populations were forced into exile. Stalin had wrongly accused them of collaborating with the Nazi invaders, and they were rounded up and packed off in freight cars to Central Asia and Siberia. The true toll may never be known, but historians believe hundreds of thousands of men, women, and children perished en route or in exile.

In 1957 Stalin's successor, Soviet leader Nikita Khrushchev, allowed the Chechens and Ingush to return home. Slowly they reclaimed their towns and villages from Russian settlers, and for nearly half a century there followed



muted acquiescence to Moscow. Yet in the final years of the Soviet Union, the Chechens were among the first to test their bonds. As independence movements sprang up from the Baltics to the Russian Far East, cries for freedom in Chechnya ignited a rebellion. On the final day of 1994 Yeltsin responded to Dudayev's declaration of an independent Chechnya by launching what is now referred to as the first Chechen war.

It would be a long, dismal campaign that pitted blundering Russian generals and teenage conscripts against a few thousand resolute Chechen guerrillas. For Moscow, the war soon devolved into a costly and deeply unpopular quagmire. For the Chechens, however, it was a war of infinite passion and pride. "Those who

fought in the first war were driven by one goal," says Timur Aliev, a Chechen journalist. "The rebels pursued a dream inherited from our ancestors: freedom."

It was a time of ascendant heroes, men who rose from obscurity to find fame in the bloodshed. Men like Shamil Basayev, a Chechen commander named in honor of the Caucasus's most fabled warrior, Imam Shamil, leader of the mountaineers' 19th-century campaigns against the tsars. In 1859 Shamil was forced to surrender to the Russians, but his holy war would live on.

Under Yeltsin, the first war ended neither in victory nor defeat. Rather, in August 1996, after the Chechen rebels swarmed back and recaptured Grozny, both sides agreed to a cease-fire.



ANTHONY SUAU (ABOVE); STANLEY GREENE, AGENCE VU



UNSPARING WAR

An abyss of grief opens before a father searching for his son in a mass grave of civilians, killed during a Russian offensive on Grozny in 1995. Human rights groups have identified more than 80 mass graves in Chechnya. Another father, his wife killed in the '95 attack, uses a cease-fire to escape with his son on a bus going to neighboring Ingushetiya (above). During the two wars, almost half of Chechnya's million people at some point fled their homeland.

For the next three years the republic languished without a functioning legal or economic infrastructure. Islamic jurisprudence, replete with sharia courts and public lashings, was introduced. Yet with the republic cordoned off from the rest of the Russian Federation by an economic quarantine, trade in kidnappings and bootleg gasoline boomed. The Chechens had won the day, but their homeland had degenerated into a lawless enclave, a magnet for Islamist extremists, and a time bomb in the center of the North Caucasus.

If in the first war the Chechen rebels were freedom fighters in an archetypal struggle of decolonization, the war that began anew in the summer of 1999—the “second war,” which

continues to smolder—marked a sharp turn. It began when some 1,200 Chechen militants invaded neighboring Dagestan in an implausible and short-lived attempt to unite the Islamic states of the North Caucasus. Then came a series of apartment bombings in Moscow and two other Russian cities.

Under the command of Vladimir Putin, a former KGB officer who succeeded Yeltsin on New Year's Eve 1999, the Russian response would be even more brutal than the first. “Our strategy is simple,” said Gennady Troshev, one of Putin's top generals. “If they shoot at us from a house, we destroy the house. If they shoot from all over a village, we destroy the village.”

By late 1999 hundreds of thousands of



Notes of hope return briefly to an abandoned, battle-scarred apartment in Grozny, where Deishi Merzuyeva, a 13-year-old war orphan, entertains a scavenging friend. Russia has allotted compensation funds—up to \$13,000 a structure—for destroyed property, but corruption has siphoned off much of the money.





CHECHNYA'S DARK AGE

War left its pitiless mark on Markha Mutalipova the day Russian helicopters attacked her village of Dyshne-Vedeno in 1995. She lost her mother—killed as she shielded Markha from an explosion—and she lost her legs. A year later three-year-old Markha sat with her new artificial limbs (left). She still lives in Chechnya, growing up in a shattered land.

Chechen civilians had fled their homes. Most went west, to neighboring Ingushetiya. Many, however, had no choice but to head south across the highest mountains in Europe, trekking for days through deep snow, often under threat from Russian warplanes. In Duisi, at the mouth of the Pankisi Gorge across the border in Georgia, I met with one group of Chechen refugees. Crowded into a long-abandoned hospital ward, its bare concrete rooms windowless and without heat, even the young ones had no trouble recognizing the Kremlin's change of tactics.

"In the first war," said Roza, a nine-year-old girl with tightly braided red hair, "we'd sit in the cellar and count the bombs. But this time there are so many bombs we can't even count them."

Soon more than 300,000 Chechens had flooded into Ingushetiya, where they lived in squalid camps. Those who remained in Chechnya, now occupied by 100,000 Russian troops, struggled to survive. By the time of Putin's inauguration in early 2000, Grozny lay in ruins for the second time in a decade. Amid the devastation, the dream of sovereignty gave way to the urge for revenge, and among the most militant the insurgency took on a new name—jihad.

Wahhabism, the most austere form of Islam, which emanates from Saudi Arabia, has held great allure for young Chechens raised on war, Russian brutality, and little else. The insurgency has long attracted foreign Islamist militants, who see the breakaway republic as both a cause to support and a potential center of global operations. But many Chechens argue that Wahhabism and other imported strains of Islam run contrary to their traditions and true identity.

"We are in danger of losing our young people to militant Islam," says Kuri Idrisov, a Chechen psychiatrist who for five years worked with refugee children in the sprawling tent camps of Ingushetiya. He and most other Chechens have watched the stream of terrorist attacks, allegedly undertaken on their behalf, in despair.

"The war has taken an unimaginable toll," says Libkhan Bazaeva, founder of a center that provides legal and medical services to Chechen women. "The extreme circumstances have radicalized society. Not only have our houses been destroyed, but our national soul is also in ruins. This is our greatest task, to rebuild it."

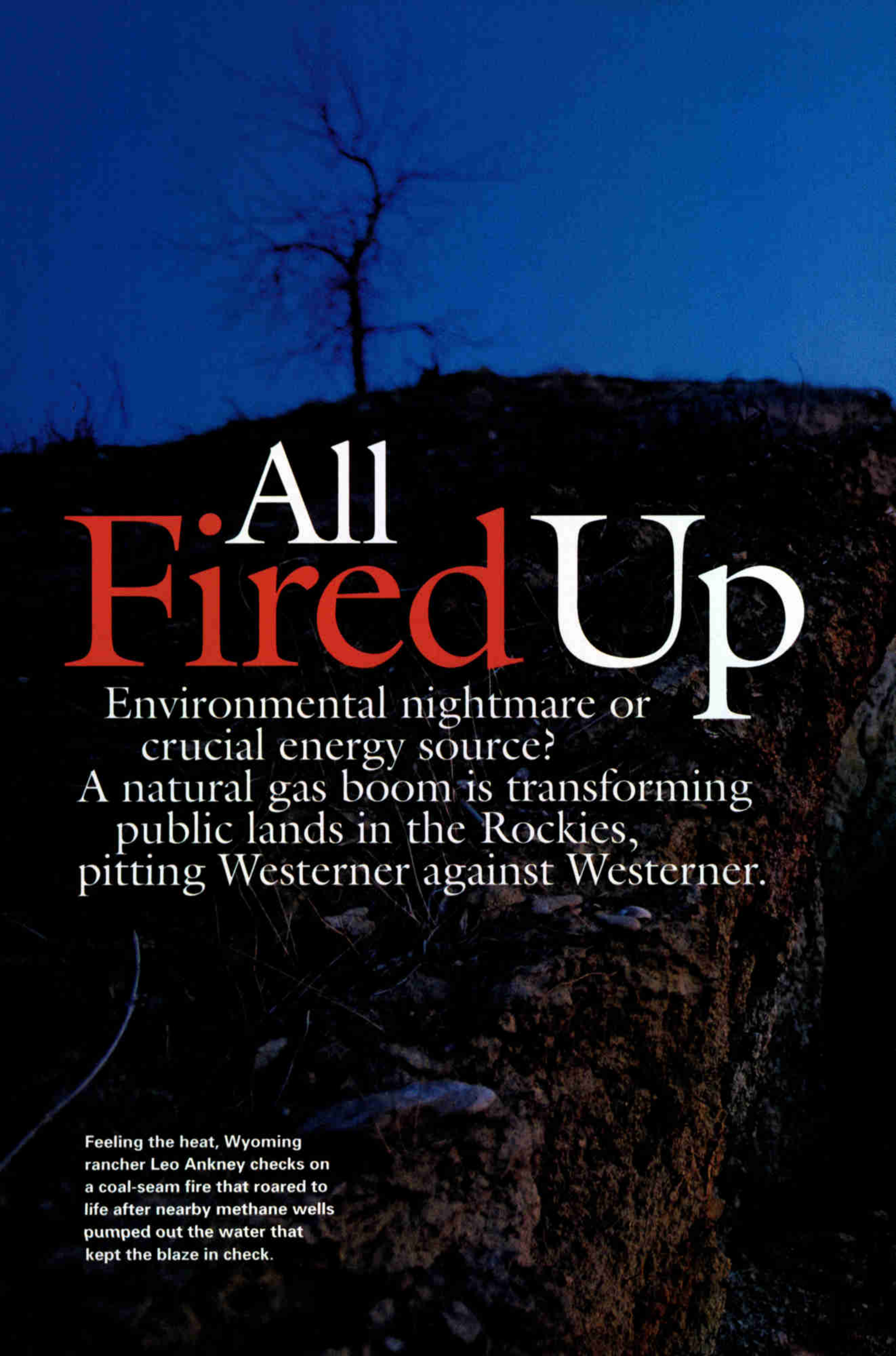
In Grozny today, much of the rubble has been cleared, but the city remains far from its

prewar state, when it was home to 400,000 residents, many of whom worked its vast petrochemical plants. Still, life has regained a rhythm. Kebab vendors are again grilling at their roadside stands, fruit markets are open downtown, and on occasion city residents—who now number some 250,000—even find traffic jams. Russian troops are still there, but many of their checkpoints have been removed, and the soldiers rarely venture from their fortified bases. At the state university, teachers such as Katya Sokirianskaia, an ethnic Russian from St. Petersburg, no longer have to lecture over bursts of gunfire outside. But Sokirianskaia has no illusions. "Very little has been done by way of real reconstruction," she says, "let alone revival of a civic life."

Worse still, the mass murder at Beslan brought the Caucasus to a new precipice. In the aftermath of the school massacre, Chechen commander Shamil Basayev, in communiqués signed "Abdallah Shamil Abu-Idris, leader of the Riyadh as-Salihiin"—the Gardens of the Righteous martyrs brigade—took credit for the raid. He has also vowed to carry on the terror campaign until Russian forces leave Chechnya.

Now Chechens no longer talk of the sovereignty they struggled for in the first war. In Grozny talk has turned to basic needs, to personal and economic security. "They're tired of Russian soldiers staging raids on their villages," says Katya Sokirianskaia of her students. "They're tired, too, of Chechen fighters taking over the same villages. They're tired of the criminal bureaucracy, of corruption and chaos. They're tired of the disappearances, the gunfire at night, the uncertain future. They're tired of it all. They want only a moment of peace." □

YOUNGEST VICTIMS Find Web links to humanitarian groups working to help children in Chechnya and Beslan, and zoom in on a satellite view of the Caucasus Mountains at nationalgeographic.com/magazine/0507.



All Fired Up

Environmental nightmare or
crucial energy source?

A natural gas boom is transforming
public lands in the Rockies,
pitting Westerner against Westerner.

Feeling the heat, Wyoming
rancher Leo Ankney checks on
a coal-seam fire that roared to
life after nearby methane wells
pumped out the water that
kept the blaze in check.



Gas Rush At a Glance

U.S. NATURAL GAS
PRODUCTION IN 2004
18.7 trillion cubic feet

U.S. NATURAL GAS
CONSUMPTION IN 2004
22.2 trillion cubic feet

AVERAGE WELLHEAD PRICE
OF NATURAL GAS IN 1998
\$1.96 per thousand cubic feet

AVERAGE WELLHEAD PRICE
OF NATURAL GAS IN 2004
\$5.49 per thousand cubic feet

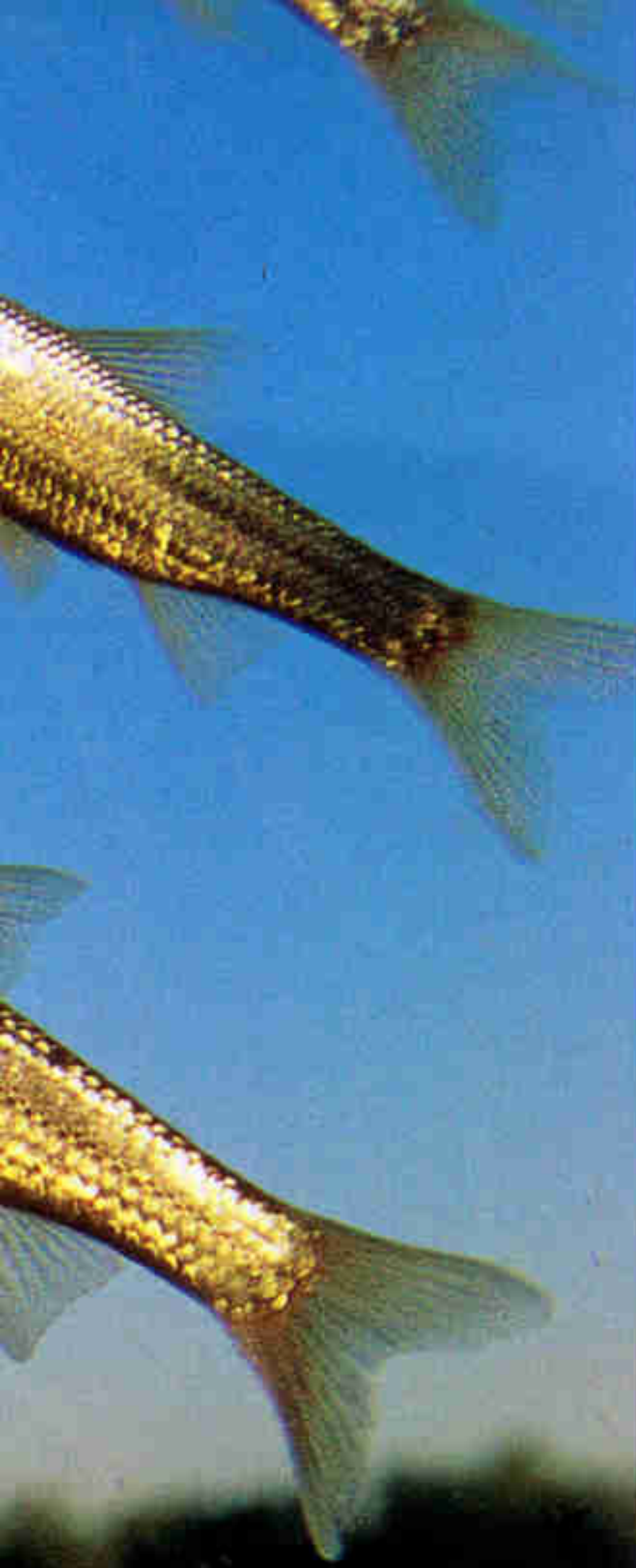
ESTIMATED INCREASE
IN U.S. DEMAND BY 2025
40 percent

NUMBER OF GAS WELLS ON
FEDERAL LANDS IN MONTANA,
WYOMING, UTAH, COLORADO,
AND NEW MEXICO
1998: 24,913
2004: 42,647

NUMBER OF NEW DRILLING
PERMITS APPROVED IN 2004 IN
MONTANA, WYOMING, UTAH,
COLORADO, AND NEW MEXICO
5,747

SOME SPECIES AFFECTED
**Greater sage grouse, pronghorn,
elk, mule deer, ferruginous
hawk, sturgeon chub**





By John G. Mitchell
Photographs by Joel Sartore

THERE ARE A NUMBER of places in the Rocky Mountains today where you will find the Old West grinding against the New, and Pinedale, Wyoming, is surely one of them. A quiet, Main Street sort of town (population 1,500) tucked behind a mesa in the sagebrush valley of the upper Green River, Pinedale is known as the home of the Museum of the Mountain Man. And this stretch of the Green is famous as the site of the riotous rendezvous that drew those buckskinned adventurers here in the waning summers of the fur trade. From hills roundabout you can see in the east the snow-dusted peaks of the Wind River Range, and the faraway Wyoming Range to westward.

This is vintage Old West scenery you're looking at. Soak it up while there's still a chance, for that other West, the New West of pipelines, thumper trucks, and drilling rigs, sits up there on the mesa and southward beyond it. To take its full measure, this West is best observed not on the ground but from the window of a single-engine plane, circling what some people regard as an environmental killing field, while others embrace it as one small but crucial platform on the path to our nation's energy independence.

Airborne, on intercom, I have Linda Baker of the Upper Green River Valley Coalition and Bruce Gordon of EcoFlight, our pilot out of Aspen, Colorado. Over the years Gordon has logged hundreds of thousands of air miles giving lawmakers and journalists the bird's-eye view of land-use battlegrounds. Now, near the Pinedale mesa's north end, Gordon is circling a place called Trappers Point, a bluff dropping off to the Green River. A scant half mile of open country is all that separates the point from a rural subdivision hugging the highway to Jackson.

"There's the bottleneck," Baker is saying. "That's one of the places the

Minnows in an aquarium appear to fly over Wyoming's Powder River, where wastewater from gas wells may threaten some species. Other natives, like gas field workers (right), are thriving, with starting pay around \$20 an hour.



pronghorn and mule deer have to squeeze through on their migration from summer range in Teton National Park into the upper Green.”

The U.S. Bureau of Land Management controls the rights to natural gas around Trappers Point, and it is uncertain when, or whether, the agency will lease it for energy development. But even if the BLM refrains from leasing the point, the migrating ungulates—sometimes numbering in the thousands—face a daunting challenge as they press farther south into their winter

one hour in practically any direction in the Rocky Mountains and look down and see some sign of oil and gas development. They’re going for it almost everywhere.”

Gordon’s perception of “almost everywhere” is not quite the same as that of the energy industry or the U.S. Geological Survey, the official arbiter of where our fossil fuel riches lie. For extracting natural gas, the Survey has identified five promising regions in the Rocky Mountains, including Wyoming’s Greater Green River Basin



Tasked by Washington to approve 3,000 drilling permits in 2004, the Bureau of Land Management field office in Buffalo, Wyoming (left, with requisite paperwork), rose to the challenge, earning a personal visit and thank-you from BLM director Kathleen Clarke.

range. It happens that the Pinedale mesa not only sits athwart the migration corridor but also overlies the Pinedale anticline, a sandstone formation containing trillions of cubic feet of natural gas. Seven hundred wells have already been approved on the mesa, and 230 are now in production. The gas fields are laced with about a hundred miles of access roads and pipelines. And as we fly south beyond the mesa, we can see the more tightly spaced well pads of the Jonah Field, with 500 more wells in place and the BLM proposing to increase that number by 3,100.

“This is a national sacrifice area,” Baker says over the intercom. I had heard it described from a different perspective just the day before at the Pinedale office of the BLM: “In terms of productivity, there are few onshore gas fields equal to the Jonah in the lower forty-eight,” said Prill Mecham, the BLM field manager.

Heading back to the airstrip at Pinedale, Gordon says, “This is just the tip of it. I can fly

(map, facing page). They range across 60 million acres managed by the federal government, plus millions of acres of state and private land, from New Mexico north to Montana. Within those five regions the federal lands alone are said to contain enough “technically recoverable” gas to supply current U.S. demand for six years.

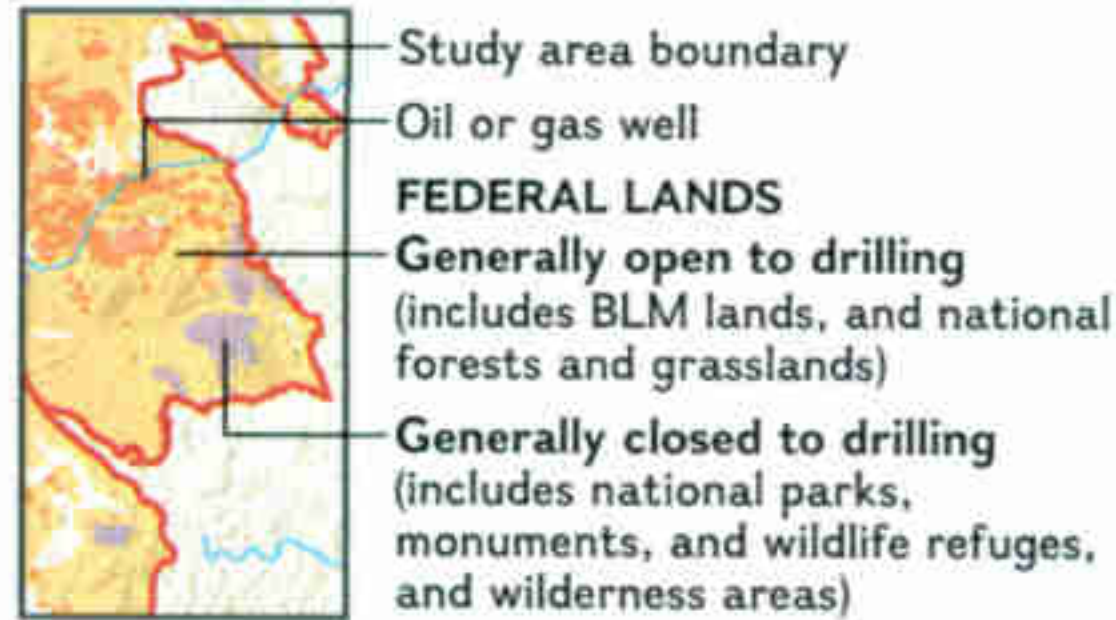
That bit of industry jargon is an important qualifier, for it means that while the technology exists to get the gas out of the ground, actually doing so may be prohibitively expensive. What’s more, drilling advocates and their opponents still debate exactly how much of this gas might be available for development. The Bush Administration’s 2001 National Energy Policy report claimed that about 40 percent of natural gas resources on federal land in the Rocky Mountain region is off-limits due to land-use restrictions or environmental safeguards. Yet opponents cite a 2003 joint study by the Interior, Energy, and Agriculture Departments that found only 12

Public Lands At Risk

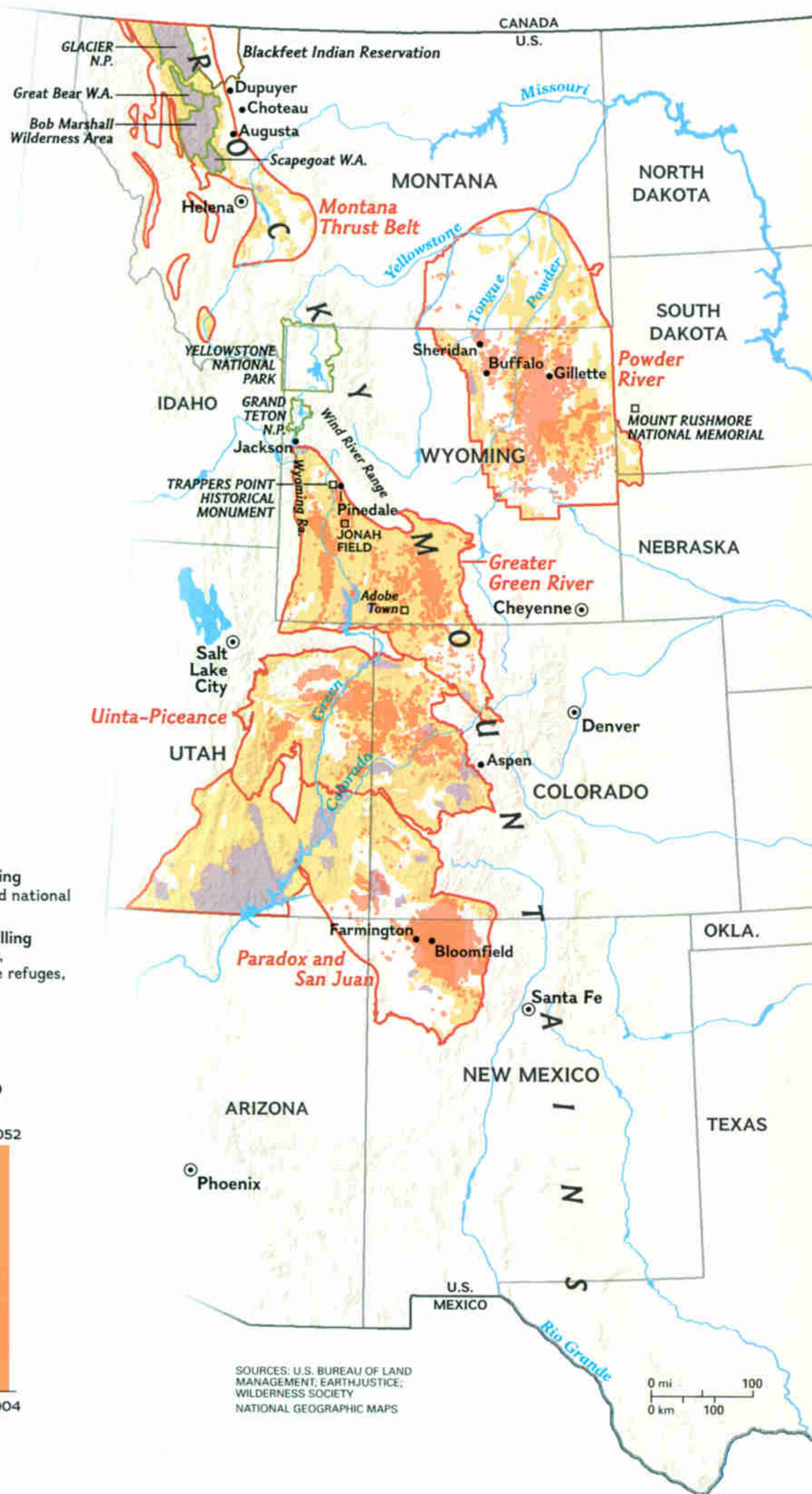
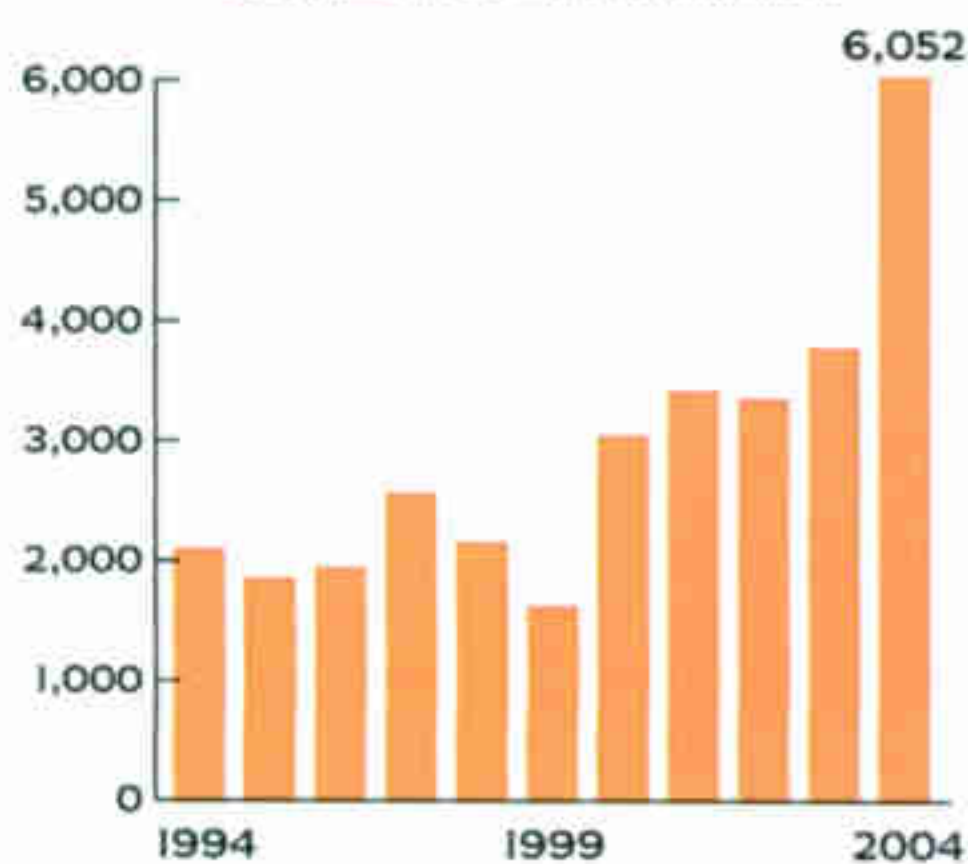


A multiyear study of oil and gas resources under federal lands focused on five areas in the Rocky Mountain region that may harbor enough natural gas to satisfy U.S. demand for six years. Most of the gas is difficult to extract and remains economically unrecoverable—too costly to tap. But new drilling technology, rising gas prices, and an energy-focused administration are fueling a dramatic rise in drilling on the federal estate.


ENERGY STUDY AREA



DRILLING PERMITS APPROVED ON ALL FEDERAL LANDS



SOURCES: U.S. BUREAU OF LAND MANAGEMENT; EARTHJUSTICE; WILDERNESS SOCIETY; NATIONAL GEOGRAPHIC MAPS



In ten years Wyoming's Jonah Field turned from sagebrush into one of the nation's richest gas fields, with 500 wells. A new proposal would pack in 3,100 more. "Basically, you'd have disturbance everywhere with little green spaces in between," says a BLM field manager.



“We understand the need to drill. What we don’t understand is the destruction of our ranches in the process.”

RANCHER LINN BLANCETT

percent of the resource unavailable for leasing. Or, as some would sum up the situation, 88 percent is up for grabs.

Another issue: On BLM land nationwide, drillers are working fewer than half the leases they already hold. A study by the Wilderness Society, for example, estimates that of the 45,836 oil and gas leases supervised by the BLM, more than half were not producing as of last February. So what has been fueling the drive to poke new holes into the well-punctured crown of our continent when there already appears to be a surfeit of untapped leases? Some energy analysts attribute it to the slow pace of domestic production in recent years, which, coupled with increased demand, pushed up the price of natural gas. Then, of course, there is the environmental advantage that gas, which burns cleaner than coal, holds over its grimy fossil cousin. And finally there was and is the Bush-Cheney energy plan, drafted behind closed doors by a vice president and other insiders with private-sector résumés reeking of petroleum. Out of this plan emerged the White House Task Force on Energy Project Streamlining, conceived as a



When drilling began 250 yards from Rick Weinheimer’s Colorado dream house (left) in 2004, the peace, quiet, and local elk herd vanished, along with his property value. In Bloomfield, New Mexico (above), a natural gas plant looms over the cemetery and everyday life, but generates jobs and taxes.



kind of ombudsman to sort out the differences between an impatient industry and red-taped federal agencies, but which in practice functioned as a complaint desk for companies seeking faster access to gas fields and other resources. BLM managers throughout the Rockies received their marching orders in August 2003 when the agency issued a directive urging them to remove unnecessary restrictions on energy development and expedite the processing of drilling applications. This, BLM director Kathleen Clarke said, “will further our agency’s efforts to ensure a reliable supply of affordable energy, as called for by the President.”

It was the unfolding of these plans and policies, and the outcry against them—often by unlikely coalitions of ranchers, hunters, outfitters, and environmental activists—that drew me last year to western battlegrounds where massive drilling threatens to change dramatically the character of unspoiled lands.

The Powder River Basin

Throughout the Rocky Mountain region, the energy industry is mostly producing two kinds of natural gas: tight sands gas, found in sandstone formations, and coal bed methane (CBM), trapped in seams of coal. The Powder River



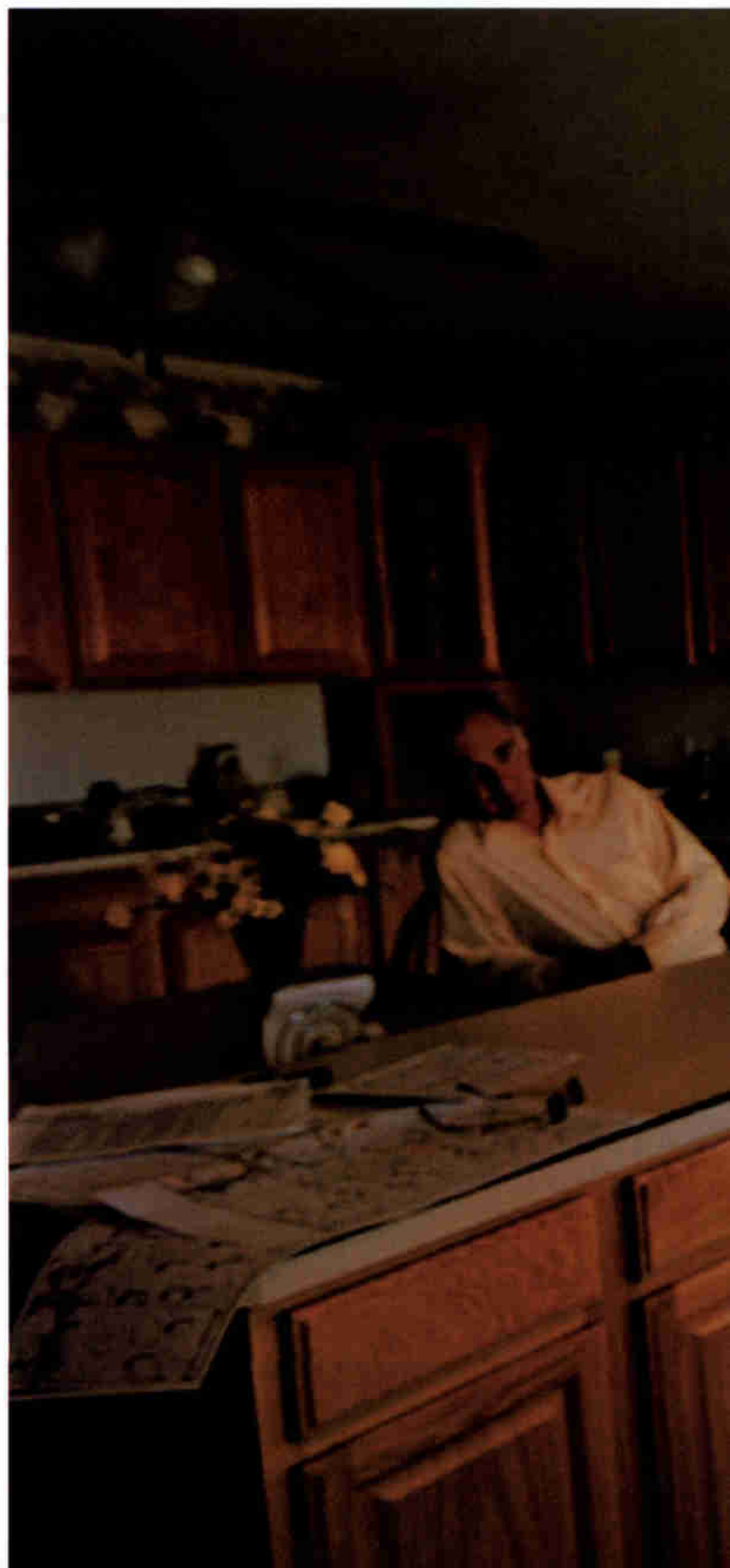
“The drilling company told us nobody had ever lost their water before,” says Powder River Basin homeowner Allison Cole (below), whose well water turned into a muddy methane slurry after drilling began nearby. Basin gas wells pump out 1.6 million barrels of water a day, some of which is atomized (left) to help speed evaporation.

Basin of northeastern Wyoming and southeastern Montana is methane country. But while the cost of drilling to reach CBM is less expensive than tapping deeper sandstone formations elsewhere, the cost of extracting it can be pricey. To release and collect the gas, drillers must first pump out the groundwater that holds the gas under pressure within the coal seams. Then the operator has to dispose of the water, often tainted with elevated levels of salinity.

As we toured some of the gas fields near Sheridan, Wyoming, Jill Morrison of the Powder River Basin Resource Council, a group that represents farmers, ranchers, and other rural residents, explained why the CBM wastewater has become such a problem. “For one thing,” she said, “the sheer quantity is staggering. We’re talking billions of gallons of water. On these clay soils here, you can’t safely irrigate with it. The salinity has a negative effect on crops and native vegetation.” Some in the gas industry and a few irrigators, however, treat the wastewater to make it usable.

A day earlier I had dropped by the BLM office in Buffalo, Wyoming, which oversees much of the state’s Powder River Basin, and spoken with Richard Zander, associate field manager. Last year this office, with more than half its staff of 80 assigned to minerals management, received a special commendation from Washington for issuing more new drilling permits than any other BLM office in the country. Some 18,000 wells are in place now, and 14,000 of them are producing about a billion cubic feet of gas daily. Another 35,000 wells are projected over the next six years.

Zander conceded there is an issue with



the water and how to get rid of it. Much of it goes into evaporation pits or reservoirs, and occasionally, I was told by Morrison and others, there have been overflows into nearby watercourses, including the Tongue River. But against that downside, Zander cited benefits accruing to landowners. Most of the mineral rights in the basin are held by the BLM, the state, or individuals other than the residential and ranching folks who “own” the surface. Zander said “nuisance fees” are paid to the surface owners by most energy companies, as much as \$2,000 for the first year of the life of a well pad, and \$1,000 a year thereafter, plus smaller sums for road and pipeline access. “For a large rancher, that could

add up to \$30,000 a year—and that’s just gravy.”

But there’s another kind of gravy in Powder River country. It is the sludge that can come out of a homeowner’s tap when CBM drillers de-water the aquifer feeding that homeowner’s well and cistern. Consider the case of Allison and Richard Cole, who believed they had found their American dream in a comfortable five-bedroom house on high, open, rolling prairie ten miles north of Sheridan. “The wild, wonderful West just opened up to us,” said Allison Cole. But soon their home and those of five other families were sitting within a horseshoe of two dozen CBM wells pumping methane and water from a formation known as the Anderson coal seam.



Expediting leases
“will further our
agency’s efforts to
ensure a reliable
supply of affordable
energy.”

BLM DIRECTOR KATHLEEN CLARKE

“We lost our water in April 2003,” Allison Cole told me. “By August 2004, five other houses here had lost their water too. The drilling company, J.M. Huber Corporation, told us, ‘The reason you have no water is that your well pump burned out.’ And I said, ‘Yeah? And the reason the pump burned out is because it had no water.’”

“It takes away the joy of living out here on the prairie,” said Richard Cole. “We’d just like to get out of here now.” And Allison added: “But we can’t even put the house on the market. Who wants to buy a house without running water?”

A Huber spokesman said there is “no evidence” that the well failures have been caused by drilling activities. He cited other possible factors such as the region’s lengthy drought and increasing residential development in the area. As part of what it calls its “Good Neighbor” policy, Huber refills the Coles’ and other cisterns weekly with trucked-in water, and it has proposed constructing a replacement water supply system for all the affected landowners.

The Front

By most accounts, nothing can match Montana’s Rocky Mountain Front for its capacity to inspire awe—for the striking visual quality of its primitive landscapes, for the biological integrity of its layered habitats, and for its ark-like concentration of charismatic critters. From the edge of Glacier National Park and the Blackfeet Indian Reservation on the north, the escarpment of the Front sweeps south a hundred miles, past the Badger–Two Medicine wildlands held sacred by the Blackfeet; past the eastern spires of the Great Bear, Bob Marshall, and Scapegoat Wilderness Areas; past wildlife refuges and natural areas administered by the Forest Service, the BLM, or the state. This is what the Blackfeet call “the backbone of the world.” Westward of the high-plains

hamlets of Augusta, Choteau, and Dupuyer, grasslands roll out to collide with ponderosa foothills and the mountain battlements that loom above them. There are grizzlies here. There are black bears and cougars and wolves. There are moose, elk, mule and white-tailed deer, pronghorn, bighorn sheep, mountain goats, lynx, wolverines, eagles, hawks, owls. But underlying these wild places and wild species are scores of inactive oil and gas leases. Some of these leases, though currently on hold by the BLM, could be opened for production as early as 2008, should the Bush Administration decide to do what it was ready to do, but didn’t, just a few years earlier.

On the deck of a ranch house west of Dupuyer, with the blue-gray wall of the Front rising in the distance, I spent part of a morning talking with rancher Karl Rappold—his eyes reflecting that high-plains squint that seems to come with the territory, a full, thick mustache not quite muffling the passion in his voice as he spoke of this ranch that his grandfather first homesteaded in 1882.

“I’m just the caretaker here,” he said, sweeping his arm over the plains rolling toward a rumpled mountain called Old Man of the Hills. The ranch now spreads over 7,000 acres, but Rappold leases 6,000 more from neighboring landowners. One section reaches right up the Front to touch the edge of the Bob Marshall Wilderness. With such a spread, you’d think a cattleman might be running a herd of several thousand head. Rappold runs 350 Angus. “Got to leave some feed for the deer and the elk,” he said. “And the grizzlies. They come down here too. We’ve seen two big boar grizzlies, thousand pounds each one of them. Those big old devils been wild and free all their lives, and they’re going to stay that way. This is their last stand. Right here.” To help assure that, Rappold—much to the dismay of some other ranchers roundabout—has placed some of his land under conservation easements held by the Nature Conservancy and the U.S. Fish and Wildlife Service.

For the time being, much of the Rocky Mountain Front would seem to be secure against any prospect of energy development. Rappold himself owns the mineral rights under his land, although if active leasing were to go forward on neighboring lands, federal condemnation proceedings could force him to provide something almost as unwelcome as drill pads—pipeline



and vehicular access to the neighbors' wells. Nor could Rappold ignore memories of the recent battle of Blindhorse canyon, in the foothills southwest of his ranch. A Canadian energy company was poised to sink some wells in that canyon, despite editorials deploring the project in major newspapers across Montana. The BLM, seeking public comment, received nearly 50,000 letters and e-mails, 99 percent of them opposed to drilling. What surely helped trigger that rebuff was a growing awareness that outdoor recreation, even more than ranching, might hold the key to the region's economic future. Concerns for quality hunting and fishing, and for the vitality of local businesses that cater to the needs of outdoorsmen, are not easily dismissed in western Montana. Many ranchers supplement their incomes by serving as outfitters or guides, packing hunters into the backcountry.

On the eve of the presidential election last November, the BLM placed a stop order on its study of the Blindhorse proposal and announced it would approve no new energy activity along the Front until after a "landscape level" review is undertaken in 2007. That is the same year in which a Clinton-era moratorium on leasing

Flaring off gas in the Jonah Field, a new well adds to growing emissions from drill motors, compressors, and truck traffic. Gas field pollution could cloud views of Mount Rushmore and vistas in Yellowstone National Park.

in the Front's Lewis and Clark National Forest could be lifted by the Bush Administration.

The San Juan Basin

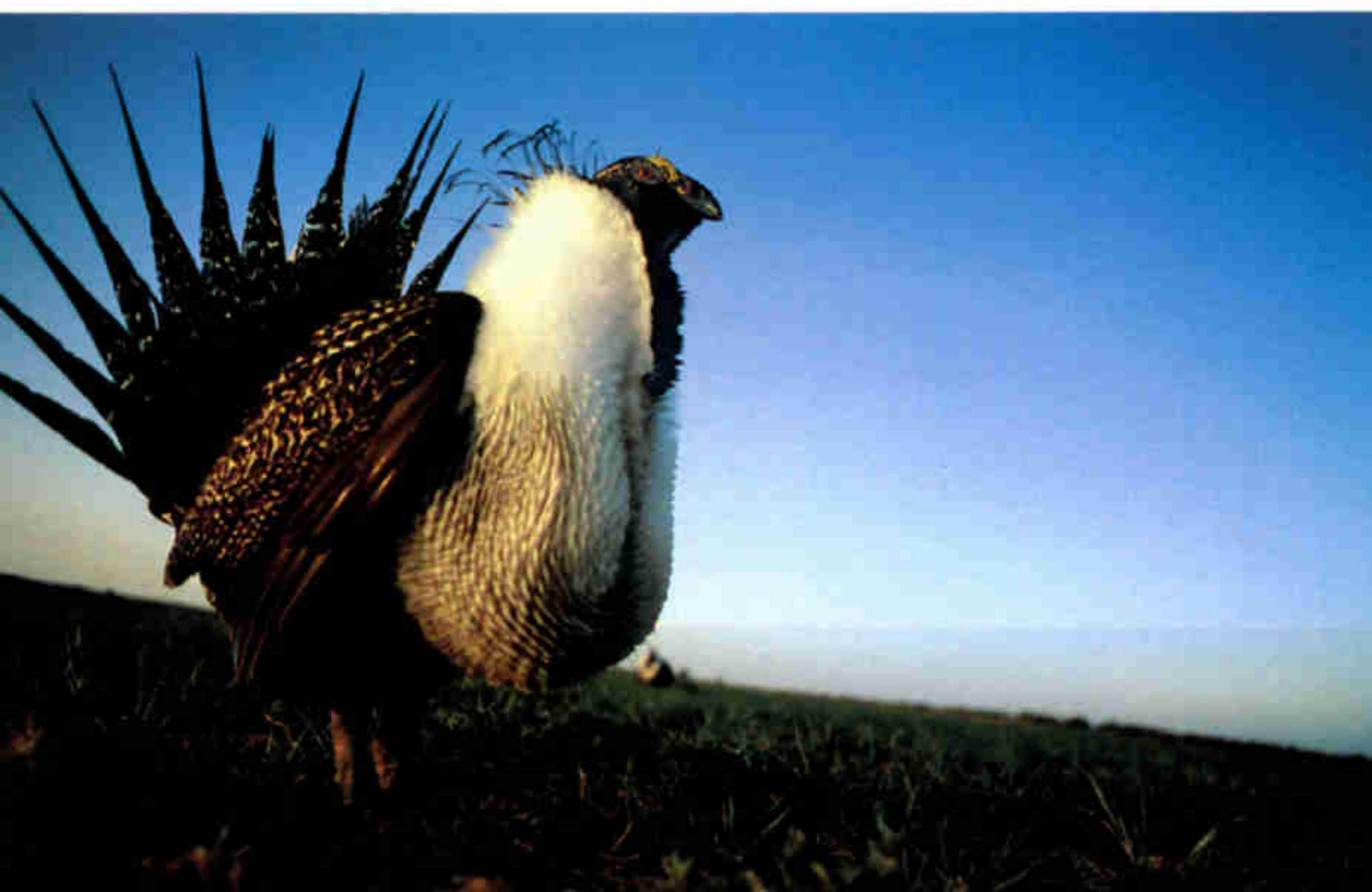
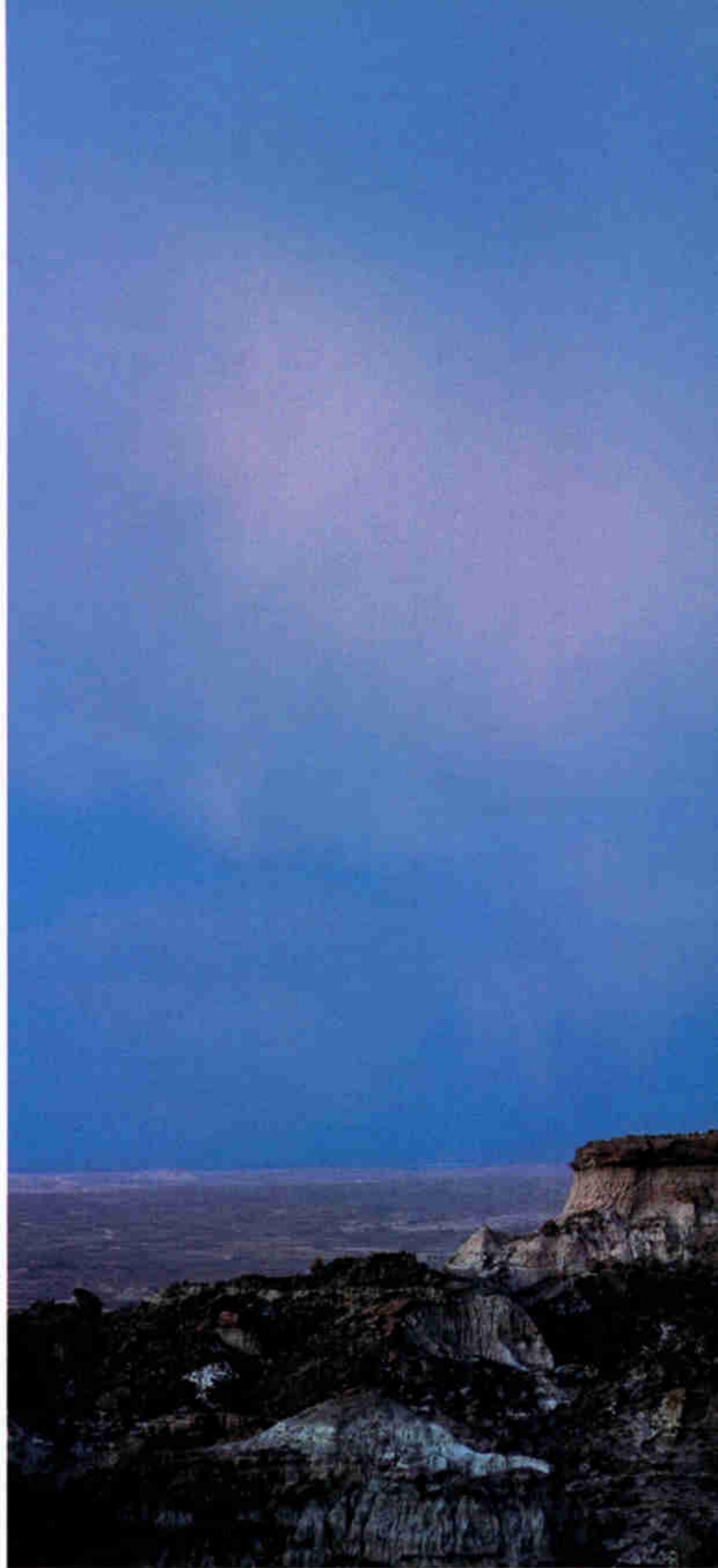
Among Anglo Americans in the Rocky Mountains, you won't find many with roots running deeper than Linn Blancett's. His cross six generations, all the way back to that first Blancett who came to the Rockies to open a trading post and founded a family line that, after a spell of ranching in Colorado, would drive its cattle south into this sere northwestern corner of New Mexico. A hundred years ago Blancetts were running more than 600 head in San Juan County. Now, on 32,000 acres of grazing land, most of which they lease from the BLM, Linn Blancett and his wife, Tweeti, are running no herd at all. They sold off all but a few of their cattle late in 2003, informing the BLM that they could no longer ranch effectively because of the agency's

failure to enforce regulations governing the 450 wells that pepper their spread. The wells and their associated compressors, pipelines, and access roads, Linn Blancett contended, had caused unmitigated erosion, loss of forage, and pollution of both air and water.

“We understand today as in the past the need to drill,” Blancett wrote in a letter last year to Steve Henke, who runs the BLM district office in Farmington. “What we don’t understand or accept is the destruction of our ranches in the process.”

Steve Henke, for his part, acknowledges that drilling for natural gas in the San Juan Basin is having some impacts; he just doesn’t see them being as serious as Linn Blancett does. “I cannot agree with those who say that ranching is no longer viable here,” Henke told me. “We’re doing everything we can to keep them in business, because ranching is not what they do—it’s who they are.”

Despite Henke’s assurances, several lawsuits are currently wending their way through the courts. One, filed against the BLM and Interior Secretary Gale Norton by three chapters of the Navajo Nation, the Natural Resources Defense Council, and Tweeti Blancett, among others, challenges a plan to authorize nearly 10,000 new oil and gas wells in the San Juan Basin over the next 20 years. Another legal action targets Burlington Resources and two other basin producers, alleging hazardous waste spills. Burlington, the basin’s most active producer, holds down a big office in Farmington employing 280 people. The man in charge there is vice president Richard Fraley. In our conversation and in a prepared statement later posted to me, Fraley said he believes that the “vast majority” of Burlington’s



Lightning crackles over Adobe Town in Wyoming’s acclaimed Red Desert, an area once proposed for wilderness protection but now proposed for drilling. Biologists believe fragmentation of such habitat and increasing traffic in gas fields is a factor in a dramatic decline of greater sage grouse in the West.



operations “fully comply with applicable federal, state, and local regulations at any given time.” The company spends about 240 million dollars annually on goods, services, and salaries in the Farmington area. And Burlington is one of the largest payers of state income and royalty taxes in the state of New Mexico.

“The bottom line,” said Fraley, “is that, unlike the Blancetts, the vast majority of ranchers are pretty happy with what we’ve been doing here.”

Linn Blancett figures he knows the reason. “Farmington is a company town,” he said. “I hardly know of a ranching family that doesn’t have somebody working for or servicing an oil

company. This is the employment base.” By some accounts, the happier ranchers are those who can look forward to substantial mineral-rights royalties and other industry payments to offset their ranching losses.

Trappers Point

I had come to Pinedale, Wyoming, to check out that wildlife migration corridor across the Pinedale mesa, but had seen it only from the air. Now I wanted to have a look at that special place called Trappers Point, this time with my feet on the ground. I also needed to check out reports that at least one energy company was trying to

Hunters admire a mule deer shot near Choteau, Montana, part of the Rocky Mountain Front. Outdoorsmen joined environmentalists last year to stave off drilling in the region. BLM's plan drew some 50,000 comments, with 99 percent opposed.





minimize the impact of its drilling. So I called on Ronald E. Hogan, general manager of Questar Market Resources, a Utah firm that has been poking into the Pinedale anticline for 40 years. Questar operates 106 wells up on the mesa. It is aiming to have 350 more in place before 2012. “You know,” he said, “there’s 20 trillion cubic feet of gas in that anticline. That’s enough to supply the entire United States for a year.”

Hogan explained how Questar was trying to work out an agreement with the BLM that would allow the company to expand its drilling during the winter months. At the time, most drill rigs, heavy equipment, as well as the public at

large were barred from the mesa November to May to avoid disturbing the wildlife. But Hogan argued that lifting some winter restrictions would let Questar employ a technology called directional drilling, by which a single drill rig can tap distant gas deposits. This would allow the company to reduce the number of projected new drill pads, cut the duration of its drilling operations on the mesa from 18 to 9 years, and improve the economic stability of the community by keeping its workforce dependent on local services year-round, instead of seasonally. (Several months after our tour of the mesa, the BLM approved Questar’s proposal when it



Home to reclusive grizzlies, bighorn sheep (right), and reserves of natural gas, Montana's Rocky Mountain Front (below) epitomizes the debate over energy development in the West. "We can't go on forever gobbling up natural resources," says Front resident Chuck Blixrud. "We've got to do something different."



issued a "Finding of No Significant Impact.")

Leaving Hogan's Pinedale office, I pulled off the highway where a small sign pointed the way to Trappers Point Historical Monument. At the top of a steep dirt track, posted inside a small enclosure, the stenciled legend on a marker set the scene. "Along the river banks below are the Rendezvous sites of 1833, 1835, 1836, 1837, 1839, 1840. . . . Trappers, traders and Indians from throughout the west here met the trade wagons from the east to barter, trade for furs, gamble, drink, frolic, pray and scheme." But the legend says nothing of how the beaver trade, the first great exploitation of the West, ended in the campfire smokes of that last rendezvous. By 1840 the beaver had been virtually extirpated from the mountains, trapped out at the rate of 100,000 a year. On the boulevards of New York and Paris, dandies would be doffing a new kind of hat. It was made of silk.

It's said that the Pinedale anticline could be producing until 2040, at which point the recoverable gas will probably be gone. What a timely but poignant end to it that would be. Standing there above the Green River, I imagined the Museum of the Mountain Man getting all decked out to observe the bicentennial of the last rendezvous. Perhaps the city fathers would be opening a new exhibit: the Museum of the Fossil Fuel Man. Who was that wise scholar who once said that the only thing we learn from history is that we learn nothing from history? □

THE TRUE COST OF ENERGY is more than dollars and cents, says photographer Joel Sartore, who narrates a multimedia look at western gas fields. See the show, then join our online forum at nationalgeographic.com/magazine/0507.

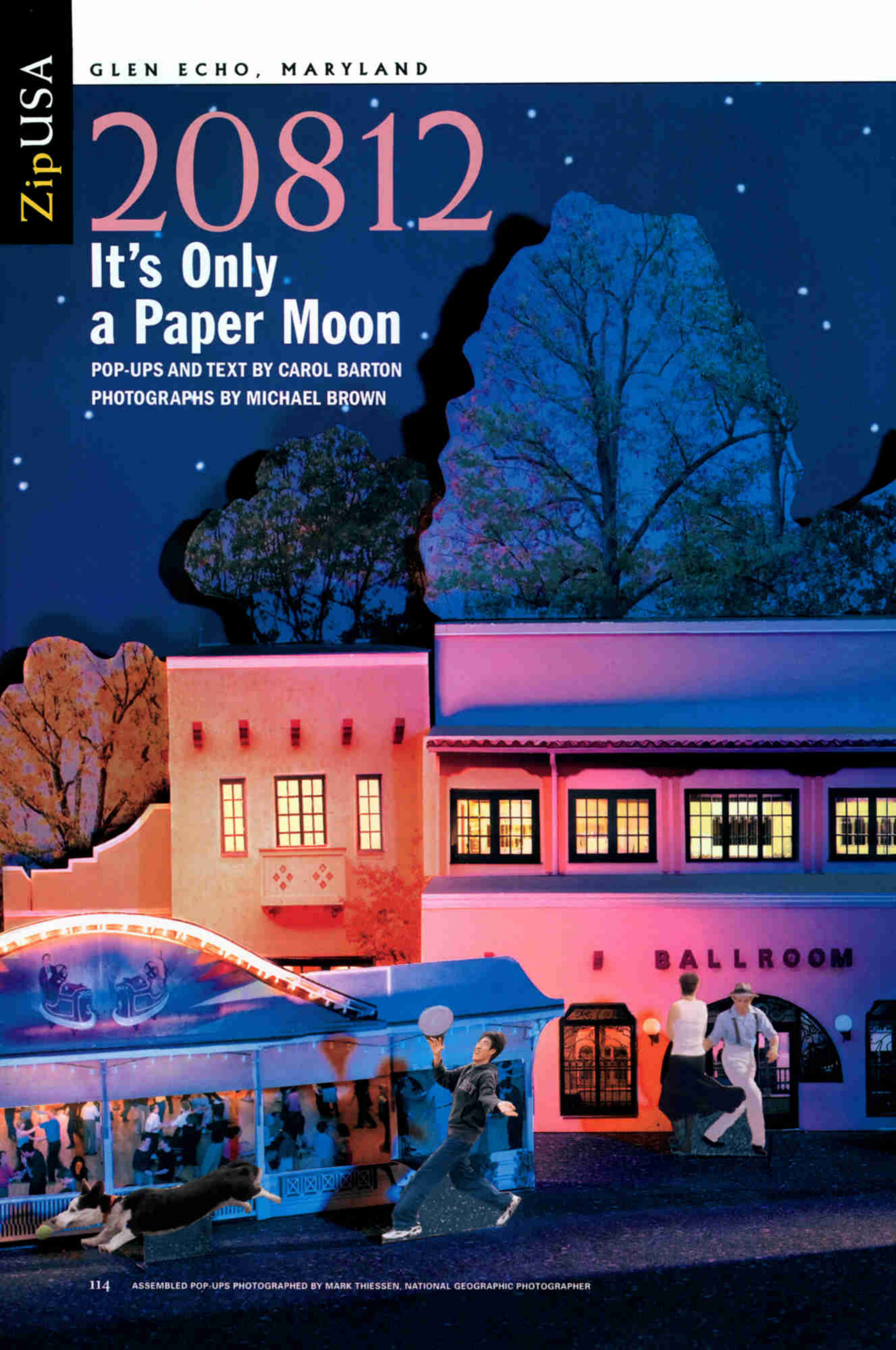
GLEN ECHO, MARYLAND

20812

It's Only a Paper Moon

POP-UPS AND TEXT BY CAROL BARTON

PHOTOGRAPHS BY MICHAEL BROWN

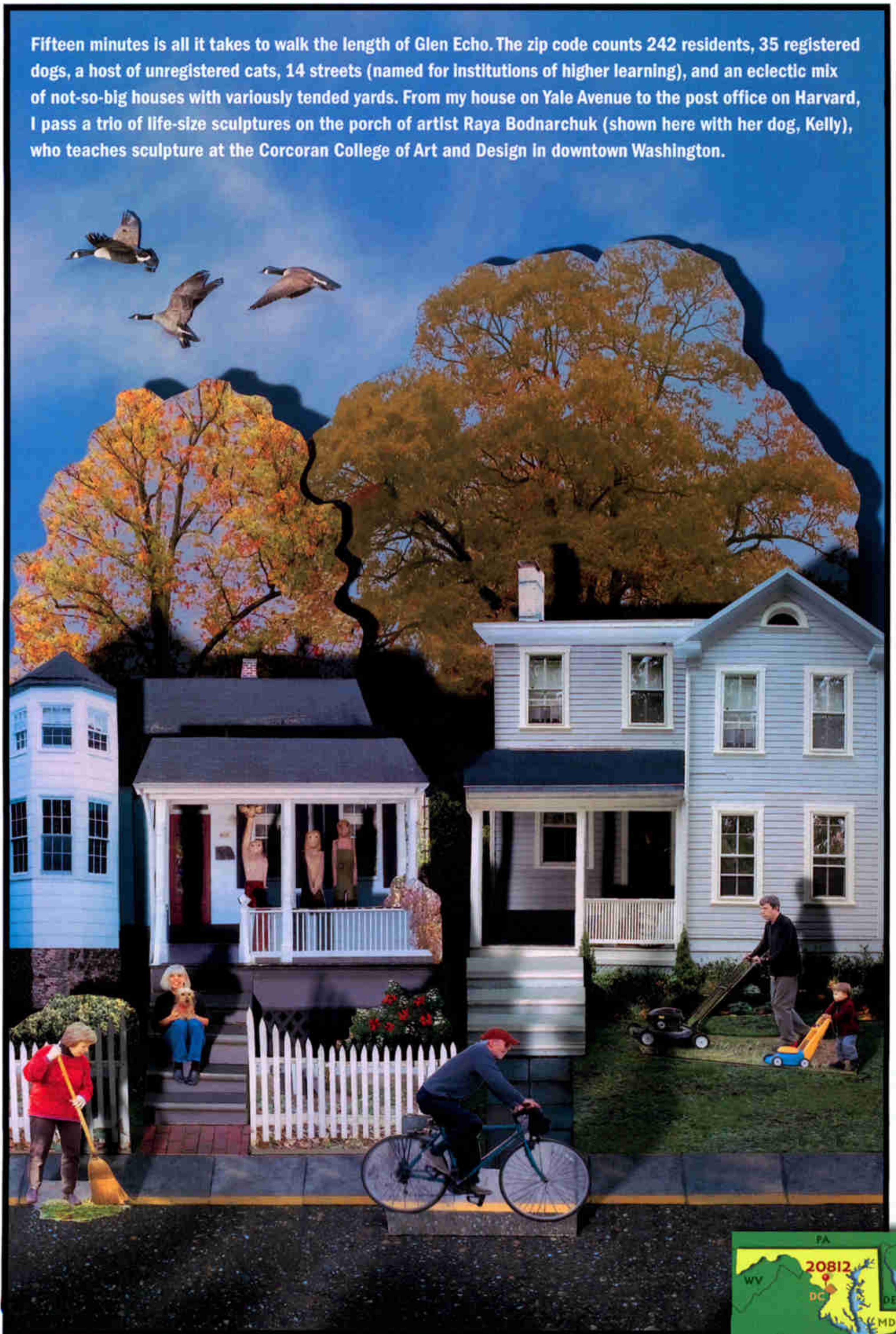


When I first stumbled across the recycled amusement park that lies at the heart of Glen Echo, Maryland, I had no idea my life was about to change. The park attracted thrill seekers from nearby Washington, D.C., and beyond from 1899 until it closed in 1968. By the time I got a job as an arts administrator at the park in 1977, it had reopened under the National Park Service as a budding arts and education center. Artists and actors worked in studios salvaged from the old amusement buildings and often settled in the adjacent town. I soon switched from painting to crafting three-dimensional books and moved into town myself. The pop-up illustrations on these pages are my attempt to capture the quirky charm of the place, where on warm summer days, visitors dance in the old bumper car pavilion or catch a ride on the 84-year-old carousel.

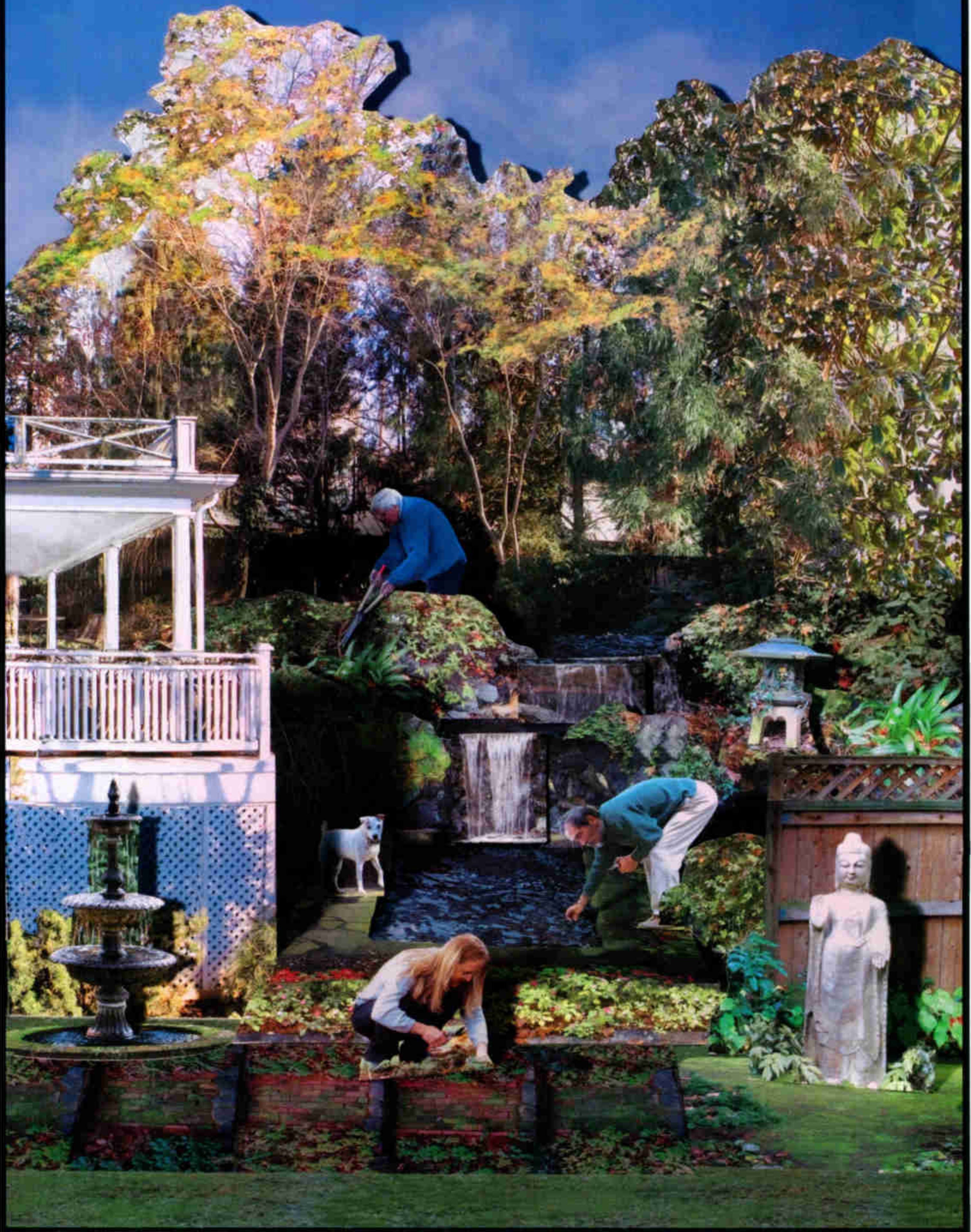


GLEN ECHO, MARYLAND

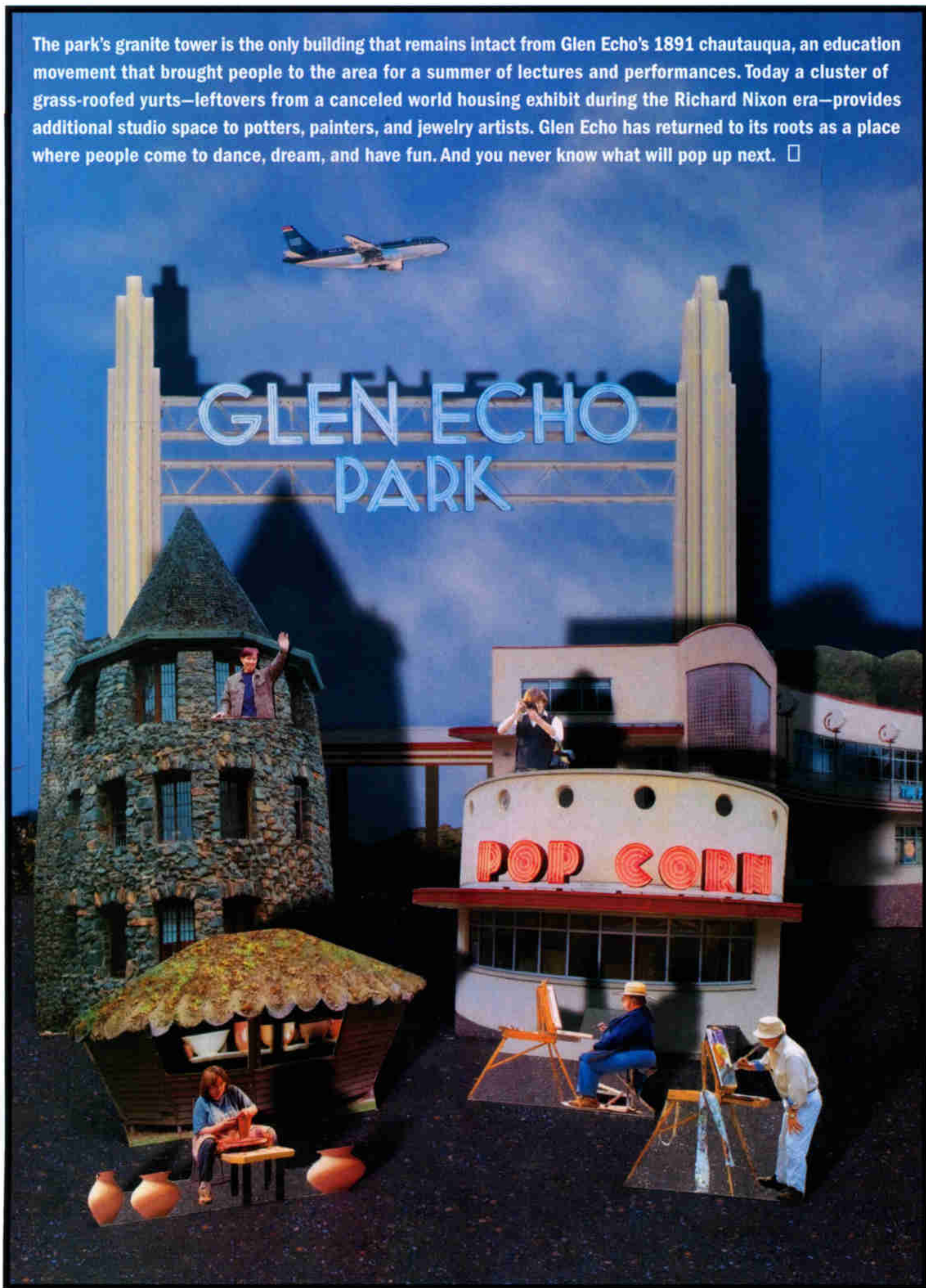
Fifteen minutes is all it takes to walk the length of Glen Echo. The zip code counts 242 residents, 35 registered dogs, a host of unregistered cats, 14 streets (named for institutions of higher learning), and an eclectic mix of not-so-big houses with variously tended yards. From my house on Yale Avenue to the post office on Harvard, I pass a trio of life-size sculptures on the porch of artist Raya Bodnarchuk (shown here with her dog, Kelly), who teaches sculpture at the Corcoran College of Art and Design in downtown Washington.



On Bryn Mawr Avenue, Holly Shimizu, executive director of Washington's U.S. Botanic Garden, and her husband, Osamu, at right, have created the ultimate garden, including a Buddha in a bed of moss and a frog-filled pool fed by a waterfall. Glen Echo neighbors often swap garden plants during the spring thinning season.



The park's granite tower is the only building that remains intact from Glen Echo's 1891 chautauqua, an education movement that brought people to the area for a summer of lectures and performances. Today a cluster of grass-roofed yurts—leftovers from a canceled world housing exhibit during the Richard Nixon era—provides additional studio space to potters, painters, and jewelry artists. Glen Echo has returned to its roots as a place where people come to dance, dream, and have fun. And you never know what will pop up next. □



MAKE YOUR OWN POP-UP Print out a pattern and follow step-by-step instructions to create your own pop-up, manipulate 180-degree models of some of the illustrations featured in this story, and watch *Glen Echo* resident Carol Barton re-create the opening amusement park scene. Then nominate your own favorite zip code for coverage in the magazine at nationalgeographic.com/magazine/0507.



Where in the world is RE/MAX?

50+ Countries.
5,000+ Offices.
100,000+ Agents.
Nobody sells more real estate.

Outstanding Agents.
Outstanding Results.[®]

www.remax.com

Final Edit



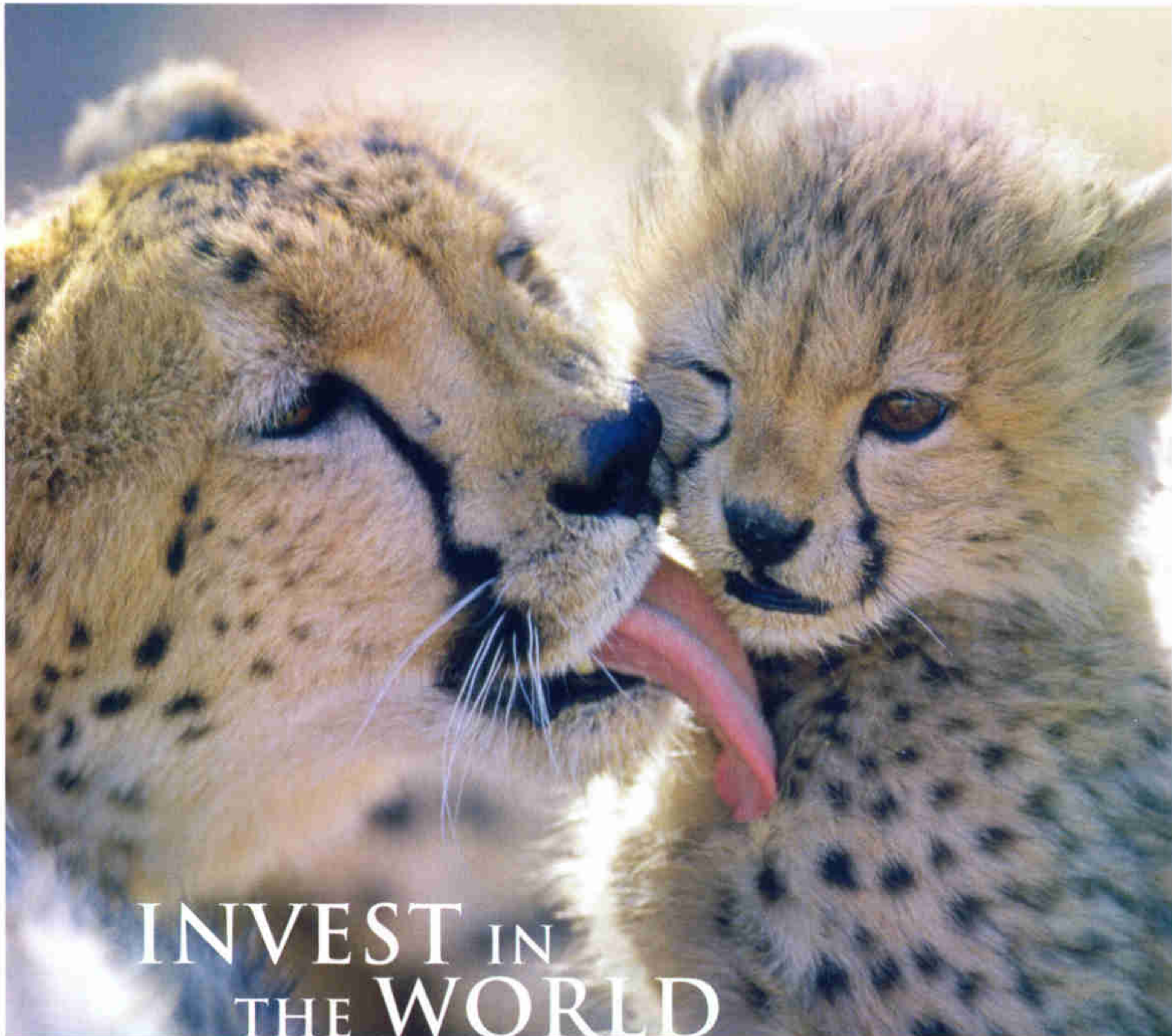
TAPPING THE ROCKIES

Country Roads

Native Nebraskan Joel Sartore cut his teeth on country roads, so when the photographer hopped in the back of a pickup carrying a young hunter's mule deer out of the Rocky Mountain Front in Montana, the scene resonated. "I've always wanted to do a dusty road picture," says Sartore, who covered the energy boom in the Rockies in this issue. "But I never had a chance until now."

For Sartore the deer and dust plume represent the ongoing battle over what's left of the wild in the lower 48. The Rocky Mountain Front still contains its full suite of species, including deer, elk, grizzlies, and wolves—as well as potentially significant natural gas reserves. For the story, editors chose the more visceral hunting photograph on pages 110-111, but the quiet emotion stirred by this image lingered . . . like a dust cloud on a windless day.

E-GREET A FRIEND and see the runner-up for Final Edit, in Departments at nationalgeographic.com/magazine/0507.



INVEST IN THE WORLD

GIVE THE GIFT THAT GIVES BACK

Establishing a gift annuity with the National Geographic Society will provide you with financial rewards for a lifetime. As an annuitant you will:

- Receive fixed and reliable annual payments for you and/or a loved one for life.
- Enjoy an immediate federal income tax deduction for a portion of your gift.
- Get a break on capital gains taxes (if you fund your annuity with long-term, appreciated securities).
- Ensure that National Geographic has the resources to continue its ground-breaking fieldwork and exploration, promote conservation and geography education, and showcase people and cultures.

For more information, please contact the Office of Gift Planning.

One-Life Charitable Gift Annuity Rates and Benefits for \$10,000

Age	Rate	Annual Income	Tax Deduction*
65	6.0%	\$600	\$2,868.70
70	6.5%	\$650	\$3,400.70
80	8.0%	\$800	\$4,585.20
90	11.3%	\$1,130	\$5,556.80

*For illustrative purposes only. Rates are recommended by the American Council on Gift Annuities, effective 7/03. Please check for rates for more than one annuitant. *Tax deductions will vary according to date and amount of gift. Always consult your advisers about philanthropic gifts.*



800-226-4438 / 202-828-6685

Office of Gift Planning
1145 17th Street, NW
Washington, DC 20036-4688

givinginfo@ngs.org
www.nationalgeographic.org/help

Do It Yourself

CHINA'S GREAT ARMADA (SEE PAGE 28)



STEVE RAYMER (ABOVE); MICHAEL YAMASHITA

GO THERE

Chinatowns of the World

Zheng He represents just one facet in a long history of Chinese exploration and migration. Chinese immigrants have created a rich array of Chinatowns where restaurants and myriad shops attract locals and visitors. Below are some of the world's best.

San Francisco, California Renowned for its exotic ambience, the district dates to the gold rush years of the mid-19th century. Kept out of the mines by racism, many Chinese men established laundries and restaurants to serve the growing city.

Singapore In a city where Chinese predominate, a "Chinatown" may seem redundant. But this is one of the world's most vibrant, drawing thousands to celebrate traditions like Chinese New Year (above).

New York City Its two square miles in lower Manhattan are crammed with restaurants and shops selling everything from fresh fish to teapots to high fashion.

Melbourne, Australia Also dating to a mid-19th-century gold rush, the enclave is famous for its Victorian architecture embellished with archways, Chinese characters, and other Asian accents.

Toronto, Canada The city's metro area counts six Chinatowns. Sam Ching's Chinese laundry, downtown, launched the oldest of them in the 1870s.

China Online

Well before the first Smiths, China had Zhengs. Chinese lore credits a legendary emperor with introducing the world's first surnames more than 4,000 years ago. Later they were listed in the poem "Baijiaxing"—"Hundred Surnames" (there are actually 438 of them). See the names and learn more at geo.cities.com/tokyo/3919/hundred.html. Or go to www.mandarintools.com/chinesename.html to create your own Chinese name derived from your birthday, sex, Western name—and the essence you want the name to reflect.

WEBSITE EXCLUSIVE Photographer Mike Yamashita followed in the wake of Zheng He's journeys. View his online gallery with photo tips at nationalgeographic.com/magazine/0507.

PICKS

3 exports


Photo editor **Elizabeth Krist**, who worked on the armada story, found that many of the goods traded along Zheng's route are still popular today. Here are her top three:

■ **Silk** China's most famous export, silk has long been used to craft shimmering clothing and intricate decorations. But before the Chinese invented paper, calligraphers used rolls of it for official documents.

■ **Medicinal products** Traditional Chinese healing uses plant and animal products like sage and deer antlers. Some items, made from endangered animal parts, are no longer traded legally, but others can be found at Chinese herbalists' shops.

■ **Spices** Prized in the West since at least the early Roman Empire, aromatic spices were heavily traded by European and Chinese explorers. Spices remain hot commodities at open-air markets like this one in Yemen.





we have
what you
want

ngsimages.com

**Stock & assignment
photography:**
(professional art
buyers only)
ngsimages.com

**Photographic
prints & posters:**
allposters.com

**Mobile phone
wallpaper:**
Verizon Wireless
Alltel
U.S. Cellular

Flashback



B. ANTHONY STEWART

TAPPING THE ROCKIES

Well, Well, Well...

Centuries ago the Gabrielino Indians relayed messages to each other from the top of a hill overlooking California's Pacific coast. But by 1941, when this photograph was taken, Signal Hill, near Long Beach, bristled with oil derricks. Discovered in 1921, the town's oil field became one of the most productive for its size in the world—so productive that relatives of those buried in a local cemetery received royalties for the oil pumped from beneath family graves.

—Margaret G. Zackowitz

FLASHBACK ARCHIVE All the photos plus e-greetings, in Departments at nationalgeographic.com/magazine/0507.



Max Stuhrling's big mistake

He handmade too many of his most spectacular timepiece

The fine horologists (watchmakers) at the Stuhrling just built a super luxury watch for last Christmas. Using one of the most complex regulator movements ever designed, they engineered the Regulator Series 3. With its large separate minute dial and small hour dial, this watch is considered to be among the most beautiful watches ever designed. Well, Max made a mistake. You see, his company is a boutique watchmaker, and Stuhrling built a few too many of his limited edition collector's timepiece. So, NextTen grabbed the last Regulators at a magnificent price. Max needed to liquidate these luxury watches so he came to us at NextTen. You see, NextTen

has become synonymous with high quality watches at extraordinary values. We are offering the Regulator 3 for a miraculous price—\$349.⁷⁵. This is a savings of over 90% from the suggested retail. Max is in tears but he needs the cash. When the last 3,435 watches are sold, that will be the end of them. I am keeping three for myself since I am convinced that the rare design will make this watch sought after by collectors in years to come.

What makes it special?

The regulator will make you want to learn how to tell time all over again. The regulator movement is utilized in the master clocks at observatories but Stuhrling has miniaturized this complex movement for the Regulator Series 3. Separate hour and minute dials will make you stare at

this unique watch. The dial is machined in a silver-white starburst and the escapement is visible through the dial so you can watch the balance wheel in action. The movement oscillates at 21,600 vibrations per hour for accuracy to within seconds per day. The tonneau styled case is clad in 23 k gold and the alligator embossed band is fitted with the finest butterfly clasp that we have seen in our travels. If you desire the best, the unique and the rare, The Regulator 3 is built for you. We do expect to be out of this watch soon so, please act quickly. Maybe Max will be more careful next time.

Stuhrling Regulator Watch

5 Payments of \$69.²⁵ +S&H

Promotional Code SRW154-02

Please mention this when you call.

To order by mail, please call for details.

NEXTTEN

14101 Southcross Drive W., Dept. SRW154-02
Burnsville, Minnesota 55337



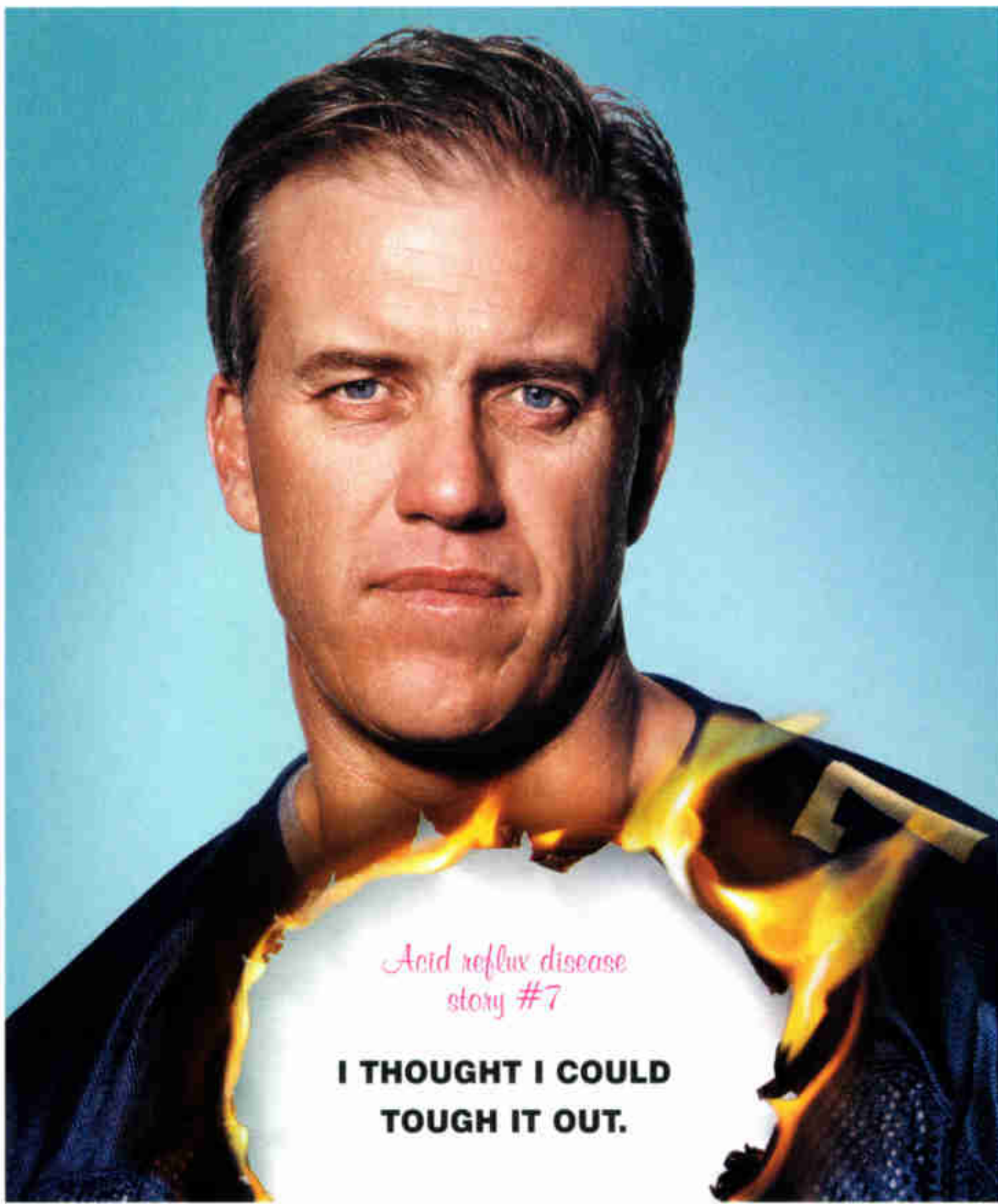
A back as beautiful as the front

The unique bronze-finished movement is absolutely stunning. You can watch the smooth movement of the rotor and the 22 jewels work in precise harmony.

For fastest service, call toll-free 24 hours a day **800-386-5195**



Visit us online at www.NextTen.com for the complete line of Watches, Jewelry and Collectibles



Acid reflux disease can affect people differently. Some people, like legendary quarterback, John Elway, feel a fireball in their chest, others get a hoarseness in their voice or a recurring sore throat. Fortunately, there's Prevacid.[®] It can be taken in many forms — one that's a pill, one you can drink, and one that disintegrates in your mouth — to help treat heartburn and many other kinds of symptoms related to acid reflux disease in many kinds of people. Maybe it's time to see if it can help yours. So ask your doctor if there's a Prevacid that's right for you.



Put it to your acid test.

For a **FREE trial certificate**, call **1-888-4PREVACID** or visit **prevacid.com** today.

Important Information: If you suffer from persistent heartburn two or more days a week, despite treatment and diet changes, it may be acid reflux disease (ARD). Heartburn is the most common symptom of ARD. Prevacid Capsules, Prevacid for Oral Suspension, and Prevacid[®] SoluTab[™] (lansoprazole) Orally Disintegrating Tablets are used to treat ARD and are not right for everyone. Individual results may vary. Prescription Prevacid has a low occurrence of side effects such as diarrhea, abdominal pain, and nausea. Symptom relief does not rule out serious stomach conditions. Please see adjacent brief summary of important information and talk to your doctor.

Brief Summary of Prescribing Information
(Nos. 1541, 1543, 1544, 3046, 7309, 7311)
Ref. Q9-5366-R24-Bf. 2 Rev. July, 2004

PREVACID[®]

(lansoprazole)
Delayed-Release Capsules

PREVACID[®]

(lansoprazole)
For Delayed-Release Oral Suspension

PREVACID[®] SoluTab[™]

(lansoprazole)
Delayed-Release Orally Disintegrating Tablets

Rx only

Indications include: Short-Term Treatment (4 weeks) of Active Duodenal Ulcer, Maintenance of Healed Duodenal Ulcers, controlled studies do not extend beyond 12 months. **Short-Term Treatment (up to 8 weeks) of Active Benign Gastric Ulcer, Healing of NSAID-Associated Gastric Ulcer,** in patients who continue NSAID use. Controlled studies did not extend beyond 8 weeks. **Risk Reduction of NSAID-Associated Gastric Ulcer,** in patients with a history of a documented gastric ulcer who require the use of an NSAID. Controlled studies did not extend beyond 12 weeks. **Gastroesophageal Reflux Disease (GERD),** Short-Term Treatment of Symptomatic GERD and Erosive Esophagitis (up to 8 weeks), for patients who do not heal with PREVACID for 6 weeks (5-10%), it may be helpful to give an additional 3 weeks of treatment. If there is a recurrence of erosive esophagitis an additional 8-week course of PREVACID may be considered. **Maintenance of Healing of Erosive Esophagitis,** controlled studies did not extend beyond 12 months. **Pathological Hypersecretory Conditions Including Zollinger-Ellison Syndrome.**

CONTRAINDICATIONS

PREVACID is contraindicated in patients with known hypersensitivity to any component of the formulation of PREVACID.

PRECAUTIONS

General

Symptomatic response to therapy with lansoprazole does not preclude the presence of gastric malignancy.

Information for Patients

PREVACID is available as a capsule, orally disintegrating tablet and oral suspension, and is available in 15 mg and 30 mg strengths. Directions for use specific to the route and available methods of administration for each of these dosage forms is available in the complete prescribing information. PREVACID should be taken before eating. PREVACID products SHOULD NOT BE CRUSHED OR CHEWED.

Phenylalanine: Contains Phenylalanine 2.5 mg per 15 mg Tablet and 5.1 mg per 30 mg Tablet.

Drug Interactions

Lansoprazole is metabolized through the cytochrome P₄₅₀ system, specifically through the CYP3A and CYP2C19 isozymes. Studies have shown that lansoprazole does not have clinically significant interactions with other drugs metabolized by the cytochrome P₄₅₀ system, such as warfarin, antipyrine, indomethacin, ibuprofen, phenytoin, propranolol, prednisone, diazepam, or clarithromycin in healthy subjects. These compounds are metabolized through various cytochrome P₄₅₀ isozymes including CYP1A2, CYP2C9, CYP2C19, CYP2D6, and CYP3A. When lansoprazole was administered concomitantly with theophylline (CYP1A2, CYP3A), a minor increase (10%) in the clearance of theophylline was seen. Because of the small magnitude and the direction of the effect on theophylline clearance, this interaction is unlikely to be of clinical concern. Nonetheless, individual patients may require additional titration of their theophylline dosage when lansoprazole is started or stopped to ensure clinically effective blood levels.

In a study of healthy subjects neither the pharmacokinetics of warfarin enantiomers nor prothrombin time were affected following single or multiple 60 mg doses of lansoprazole. However, there have been reports of increased International Normalized Ratio (INR) and prothrombin time in patients receiving proton pump inhibitors, including lansoprazole, and warfarin concomitantly. Increases in INR and prothrombin time may lead to abnormal bleeding and even death. Patients treated with proton pump inhibitors and warfarin concomitantly may need to be monitored for increases in INR and prothrombin time.

Lansoprazole has also been shown to have no clinically significant interaction with ampicillin. In a single-dose crossover study examining lansoprazole 30 mg and omeprazole 20 mg each administered alone and concomitantly with sucralfate 1 gram, absorption of the proton pump inhibitors was delayed and their bioavailability was reduced by 17% and 16%, respectively, when administered concomitantly with sucralfate. Therefore, proton pump inhibitors should be taken at least 30 minutes prior to sucralfate. In clinical trials, antacids were administered concomitantly with PREVACID Delayed-Release Capsules; this did not interfere with its effect.

Lansoprazole causes a profound and long-lasting inhibition of gastric acid secretion; therefore, it is theoretically possible that lansoprazole may interfere with the absorption of drugs where gastric pH is an important determinant of bioavailability (e.g., ketoconazole, ampicillin esters, iron salts, digoxin).

Carcinogenesis, Mutagenesis, Impairment of Fertility

In two 24-month carcinogenicity studies, Sprague-Dawley rats were treated orally with doses of 5 to 150 mg/kg/day, about 1 to 40 times the exposure on a body surface (mg/m²) basis, of a 50-kg person of average height (1.48 m² body surface area) given the recommended human dose of 30 mg/day (22.2 mg/m²). Lansoprazole produced dose-related gastric enterochromaffin-like (ECL) cell hyperplasia and ECL cell carcinoids in both male and female rats. It also increased the incidence of intestinal metaplasia of the gastric epithelium in both sexes. In male rats, lansoprazole produced a dose-related increase of testicular interstitial cell adenomas. The incidence of these adenomas in rats receiving doses of 15 to 150 mg/kg/day (4 to 40 times the recommended human dose based on body surface area) exceeded the low background incidence (range = 1.4 to 10%) for this strain of rat. Testicular interstitial cell adenoma also occurred in 1 of 30 rats treated with 50 mg/kg/day (13 times the recommended human dose based on body surface area) in a 1-year toxicity study.

In a 24-month carcinogenicity study, CD-1 mice were treated orally with doses of 15 to 600 mg/kg/day, 2 to 80 times the recommended human dose based on body surface area. Lansoprazole produced a dose-related increased incidence of gastric ECL cell hyperplasia. It also produced an increased incidence of liver tumors (hepatocellular adenoma plus carcinoma). The tumor incidences in male mice treated with 300 and 600 mg/kg/day (40 to 80 times the recommended human dose based on body surface area) and female mice treated with 150 to 600 mg/kg/day (20 to 80 times the recommended human dose based on body surface area) exceeded the ranges of background incidences in historical controls for this strain of mice. Lansoprazole treatment produced adenoma of rete testis in male mice receiving 75 to 600 mg/kg/day (10 to 80 times the recommended human dose based on body surface area).

Lansoprazole was not genotoxic in the Ames test, the *in vivo* rat hepatocyte unscheduled DNA synthesis (UDS) test, the *in vivo* mouse micronucleus test or the rat bone marrow cell chromosomal aberration test. It was positive in *in vitro* human lymphocyte chromosomal aberration assays.

Lansoprazole at oral doses up to 150 mg/kg/day (40 times the recommended human dose based on body surface area) was found to have no effect on fertility and reproductive performance of male and female rats.

Pregnancy, Teratogenic Effects.

Pregnancy Category B

Lansoprazole

Teratology studies have been performed in pregnant rats at oral doses up to 150 mg/kg/day (40 times the recommended human dose based on body surface area) and pregnant rabbits at oral doses up to 30 mg/kg/day (16 times the recommended human dose based on body surface area) and have revealed no evidence of impaired fertility or harm to the fetus due to lansoprazole.

There are, however, no adequate or well-controlled studies in pregnant women. Because animal reproduction studies are not always predictive of human response, this drug should be used during pregnancy only if clearly needed.

Nursing Mothers

Lansoprazole or its metabolites are excreted in the milk of rats. It is not known whether lansoprazole is excreted in human milk. Because many drugs are excreted in human milk, because of the potential for serious adverse reactions in nursing infants from lansoprazole, and because of the potential for tumorigenicity shown for lansoprazole in rat carcinogenicity studies, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into account the importance of the drug to the mother.

Pediatric Use

The safety and effectiveness of PREVACID have been established in pediatric patients 1 to 17 years of age for short-term treatment of symptomatic GERD and erosive esophagitis. Use of PREVACID in this population is supported by evidence from adequate and well-controlled studies of PREVACID in adults with additional clinical, pharmacokinetic, and pharmacodynamic studies performed in pediatric patients. The adverse events profile in pediatric patients is similar to that of adults. There were no adverse events reported in U.S. clinical studies that were not previously observed in adults. The safety and effectiveness of PREVACID in patients <1 year

of age have not been established.

1 to 11 years of age

The pediatric safety of PREVACID Delayed-Release Capsules has been assessed in 66 pediatric patients aged 1 to 11 years of age. Of the 66 patients with GERD, 65% (56/66) took PREVACID for 8 weeks and 15% (10/66) took it for 12 weeks.

The most frequently reported (2 or more patients) treatment-related adverse events in patients 1 to 11 years of age (N=66) were constipation (5%) and headache (3%).

12 to 17 years of age

The safety of PREVACID Delayed-Release Capsules has been assessed in these 87 adolescent patients. Of the 87 adolescent patients with GERD, 6% (5/87) took PREVACID for <6 weeks, 93% (81/87) for 6-10 weeks, and 1% (1/87) for >10 weeks.

The most frequently reported (at least 3%) treatment-related adverse events in these patients were headache (7%), abdominal pain (5%), nausea (3%) and dizziness (3%). Treatment-related dizziness, reported in this package insert as occurring in <1% of adult patients, was reported in this study by 3 adolescent patients with nonerosive GERD, who had dizziness concurrently with other events (such as migraine, dyspnea, and vomiting).

Use in Women

Over 4,000 women were treated with lansoprazole. Ulcer healing rates in females were similar to those in males. The incidence rates of adverse events were also similar to those seen in males.

Use in Geriatric Patients

Ulcer healing rates in elderly patients are similar to those in a younger age group. The incidence rates of adverse events and laboratory test abnormalities are also similar to those seen in younger patients. For elderly patients, dosage and administration of lansoprazole need not be altered for a particular indication.

ADVERSE REACTIONS

Clinical

Worldwide, over 10,000 patients have been treated with lansoprazole in Phase 2-3 clinical trials involving various dosages and durations of treatment. The adverse reaction profiles for PREVACID Delayed-Release Capsules and PREVACID for Delayed-Release Oral Suspension are similar. In general, lansoprazole treatment has been well-tolerated in both short-term and long-term trials.

The following adverse events were reported by the treating physician to have a possible or probable relationship to drug in 1% or more of PREVACID-treated patients and occurred at a greater rate in PREVACID-treated patients than placebo-treated patients. The incidence of the most common possibly or probably treatment-related adverse events with PREVACID in short-term, placebo-controlled studies were abdominal pain (2.1%), constipation (1.0%), diarrhea (3.8%), and nausea (1.3%). Results for placebo were 1.2%, 0.4%, 2.3%, and 1.2% respectively.

Headache was also seen at greater than 1% incidence but was more common on placebo. The incidence of diarrhea was similar between patients who received placebo and patients who received lansoprazole 15 mg and 30 mg, but higher in the patients who received lansoprazole 60 mg (2.9%, 1.4%, 4.2%, and 7.4%, respectively).

The most commonly reported possibly or probably treatment-related adverse event during maintenance therapy was diarrhea.

In the risk reduction study of PREVACID for NSAID-associated gastric ulcers, the incidence of diarrhea for patients treated with PREVACID was 5%, misoprostol 22%, and placebo 3%.

Additional adverse experiences occurring in <1% of patients or subjects in domestic trials are shown below. Refer to **Postmarketing** for adverse reactions occurring since the drug was marketed.

Body as a Whole - abdomen enlarged, allergic reaction, asthenia, back pain, candidiasis, carcinoma, chest pain (not otherwise specified), chills, edema, fever, flu syndrome, halitosis, infection (not otherwise specified), malaise, neck pain, neck rigidity, pain, pelvic pain; **Cardiovascular System** - angina, arrhythmia, bradycardia, cerebrovascular accident/cerebral infarction, hypertension/hypotension, migraine, myocardial infarction, palpitations, shock (circulatory failure), syncope, tachycardia, vasodilation; **Digestive System** - abnormal stools, anorexia, bezoar, cardiospasm, cholelithiasis, colitis, dry mouth, dyspepsia, dysphagia, enteritis, eructation, esophageal stenosis, esophageal ulcer, esophagitis, fecal discoloration, flatulence, gastric nodules/fundic gland polyps, gastritis, gastroenteritis, gastrointestinal anomaly, gastrointestinal disorder, gastrointestinal hemorrhage, glossitis, gum hemorrhage, hematemesis, increased appetite, increased salivation, melena, mouth ulceration, nausea and vomiting, nausea and vomiting and diarrhea, oral moniliasis, rectal disorder, rectal hemorrhage, stomatitis, tenesmus, thirst, tongue disorder, ulcerative colitis, ulcerative stomatitis; **Endocrine System** - diabetes mellitus, goiter, hypothyroidism; **Hemic and Lymphatic System** - anemia, hemolysis, lymphadenopathy; **Metabolic and Nutritional Disorders** - gout, dehydration, hyperglycemia/hypoglycemia, peripheral edema, weight gain/loss; **Musculoskeletal System** - arthralgia, arthritis, bone disorder, joint disorder, leg cramps, musculoskeletal pain, myalgia, myasthenia, synovitis; **Nervous System** - abnormal dreams, agitation, amnesia, anxiety, apathy, confusion, convulsion, depersonalization, depression, diplopia, dizziness, emotional lability, hallucinations, hemiplegia, hostility aggravated, hyperkinesia, hypertonia, hypesthesia, insomnia, libido decreased/increased, nervousness, neuritis, paresthesia, sleep disorder, somnolence, thinking abnormality, tremor, vertigo; **Respiratory System** - asthma, bronchitis, cough increased, dyspnea, epistaxis, hemoptysis, hiccup, laryngeal neoplasia, pharyngitis, pleural disorder, pneumonia, respiratory disorder, upper respiratory inflammation/infection, rhinitis, sinusitis, stridor; **Skin and Appendages** - acne, alopecia, contact dermatitis, dry skin, fixed eruption, hair disorder, maculopapular rash, nail disorder, pruritus, rash, skin carcinoma, skin disorder, sweating, urticaria; **Special Senses** - abnormal vision, blurred vision, conjunctivitis, deafness, dry eyes, ear disorder, eye pain, otitis media, parosmia, photophobia, retinal degeneration, taste loss, taste perversion, tinnitus, visual field defect; **Urogenital System** - abnormal menses, breast enlargement, breast pain, breast tenderness, dysmenorrhea, dysuria, gynecomasia, impotence, kidney calculus, kidney pain, leukorrhea, menorrhagia, menstrual disorder, penis disorder, polyuria, testis disorder, urethral pain, urinary frequency, urinary tract infection, urinary urgency, urination impaired, vaginitis.

Postmarketing

On-going Safety Surveillance: Additional adverse experiences have been reported since lansoprazole has been marketed. The majority of these cases are foreign-sourced and a relationship to lansoprazole has not been established. Because these events were reported voluntarily from a population of unknown size, estimates of frequency cannot be made. These events are listed below by COSTART body system.

Body as a Whole - anaphylactoid-like reaction; **Digestive System** - hepatotoxicity, pancreatitis, vomiting; **Hemic and Lymphatic System** - agranulocytosis, aplastic anemia, hemolytic anemia, leukopenia, neutropenia, pancytopenia, thrombocytopenia, and thrombotic thrombocytopenic purpura; **Skin and Appendages** - severe dermatologic reactions including erythema multiforme, Stevens-Johnson syndrome, toxic epidermal necrolysis (some fatal); **Special Senses** - speech disorder; **Urogenital System** - urinary retention.

Laboratory Values

The following changes in laboratory parameters for lansoprazole were reported as adverse events:

Abnormal liver function tests, increased SGOT (AST), increased SGPT (ALT), increased creatinine, increased alkaline phosphatase, increased globulins, increased GGTP, increased/decreased/abnormal WBC, abnormal AG ratio, abnormal RBC, bilirubinemia, eosinophilia, hyperlipemia, increased/decreased electrolytes, increased/decreased cholesterol, increased glucocorticoids, increased LDH, increased/decreased/abnormal platelets, and increased gastrin levels. Urine abnormalities such as albuminuria, glycosuria, and hematuria were also reported. Additional isolated laboratory abnormalities were reported.

In the placebo controlled studies, when SGOT (AST) and SGPT (ALT) were evaluated, 0.4% (4/978) placebo patients and 0.4% (11/2677) lansoprazole patients had enzyme elevations greater than three times the upper limit of normal range at the final treatment visit. None of these lansoprazole patients reported jaundice at any time during the study.

OVERDOSAGE

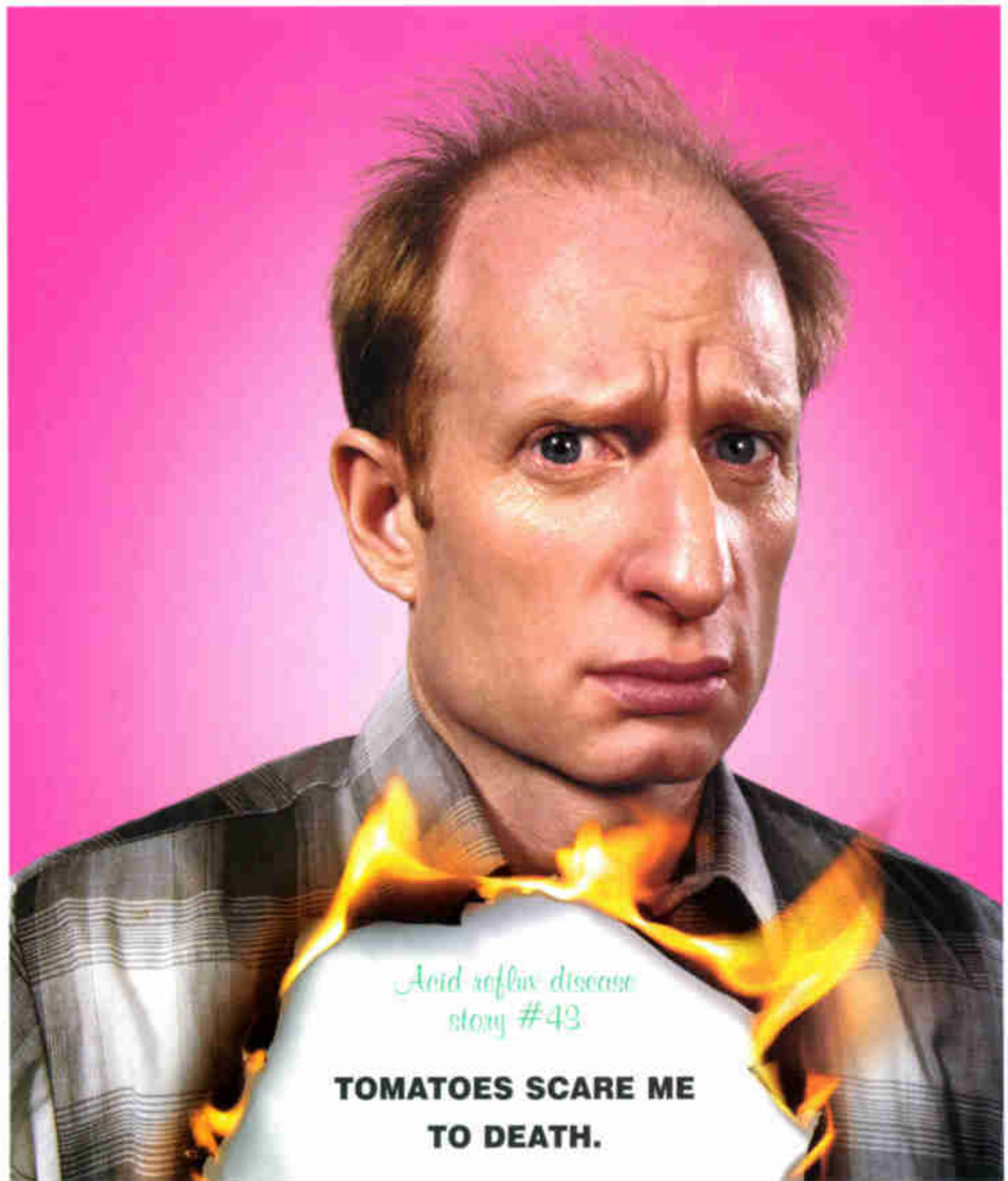
Oral doses up to 5000 mg/kg in rats (approximately 1300 times the recommended human dose based on body surface area) and mice (about 675.7 times the recommended human dose based on body surface area) did not produce deaths or any clinical signs.

Lansoprazole is not removed from the circulation by hemodialysis. In one reported case of overdose, the patient consumed 600 mg of lansoprazole with no adverse reaction.

 Distributed by
TAP Pharmaceuticals Inc.
Lake Forest, IL 60045, U.S.A.

03-5366-R24 Rev. July, 2004
© 1995-2004 TAP Pharmaceutical Products Inc.
For more detailed information, see full prescribing information or contact TAP Medical Information at 1-800-622-2011.

MR030-0155



People can have different experiences with acid reflux disease. Some have difficulty sleeping at night, while others feel an intense burning after a meal.

Fortunately, there's Prevacid®. It can be taken in many forms — one that's a pill, one you can drink, and one that disintegrates in your mouth — to help treat heartburn and many other kinds of symptoms related to acid reflux disease in many kinds of people. Maybe it's time to see if it can help yours.

So ask your doctor if there's a Prevacid that's right for you.



Put it to your acid test.

For a **FREE trial certificate**, call **1-888-4PREVACID** or visit **prevacid.com** today.

Important Information: If you suffer from persistent heartburn two or more days a week, despite treatment and diet changes, it may be acid reflux disease (ARD). Heartburn is the most common symptom of ARD. Prevacid Capsules, Prevacid for Oral Suspension, and Prevacid® SoluTab™ (lansoprazole) Orally Disintegrating Tablets are used to treat ARD and are not right for everyone. Individual results may vary. Prescription Prevacid has a low occurrence of side effects such as diarrhea, abdominal pain, and nausea. Symptom relief does not rule out serious stomach conditions. Please see adjacent brief summary of important information and talk to your doctor.



NO INTELLIGENT LIFE OUT HERE. JUST YOU.



4RUNNER | MOVING FORWARD ►

Stay ahead of your better judgement with available features like a 270-hp V8 with VVT-i and full-time 4-wheel drive. Then return home to tell about it thanks to the Star Safety System,[™] exclusively from Toyota. toyota.com

STAR[™]
SAFETY SYSTEM

Vehicle shown with available equipment. ©2005 Toyota Motor Sales, U.S.A., Inc.